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EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.Z.S., F.R.M.S.,

LATE OF THE BRITISH MUSEUM OF NATURAL HISTORY;

PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,

VICE-PRESIDENT OF THE ZOOLOGICAL AND MALACOLOGICAL SOCIETIES;

MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE INSTITUTION OF MINING AND METALLURGY, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND SOUTH AFRICA; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S., &c.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VIII.

No. I.—JANUARY, 1901.

ORIGINAL ARTICLES.

I.—Note on the Structure of Sarsens.

By Professor J. W. Judd, C.B., LL.D., F.R.S., V.P.G.S., etc.

[*Introductory Note.*—After the publication of my paper on the Sarsens, or Sarsen Stones, in the Wiltshire Archæological and Natural History Society's Magazine, vol. xxiii (1886), pp. 122–154, many friendly communications gave me further information on the subject, and additional references to published facts and opinions. From this correspondence, and my own notes made in the country, I propose to utilize much that seems to be of interest. The most important of these additions to our knowledge of the Sarsens is the following memoir on their constitution and structure by my friend Prof. Dr. J. W. Judd, C.B., F.R.S., etc., of the Royal College of Science, who most obligingly examined with care the microscopical structure of many specimens from authenticated localities. With his kind permission this valuable communication (dated March 9th, 1888) is here printed.—T. Rupert Jones.]

THE microscopic examination of a series of thin sections, cut from the Sarsens, shows that their minute structure varies as strikingly as does the appearance of their fractured surfaces. Microscopically, the Sarsens are seen to be made up of two kinds of materials, clastic fragments of crystalline minerals and a cement (base or matrix) of a microcrystalline or cryptocrystalline character. The relative proportion of these two constituents varies very widely in different cases.

The Sarsens with saccharoid fracture stand at one end of the series. An admirable example from Camberley, North Surrey, is seen to be almost wholly made up of sand grains, with very little in the way of cement visible. Much of the cementing material in this rock is ferruginous, and the rock is more incoherent than is the case with most Sarsens.

At the other end of the series stand the Sarsens exhibiting a fracture resembling that of some cherts. Under the microscope the greater part of their mass is seen to be made up of excessively minute and imperfectly developed quartz microlites, and these

occasionally exhibit a tendency to the spherulitic arrangement. A beautiful example of this kind of Sarsen is one from Poxwell Ring, near Dorchester. In this case the original sand grains seem to have almost wholly disappeared, and an aggregate of grains of secondary quartz has been formed, which crystallize out freely on the sides of cavities. In parts, the section shows admirable spherulitic structure, and the iron-oxides have separated into small globular masses. The appearances exhibited are strikingly like those of some flints with highly crystalline structure.

All the other sections examined show the detrital crystalline particles enveloped in more or less of the fine-grained secondary matrix. The detrital grains consist mainly of quartz. By far the greater part of these quartz grains exhibit the bands of liquid cavities so characteristic of the quartz of granites and gneisses; corroded quartz grains with glass or stone cavities, evidently derived from quartz-felsites, occur, but are much less rare, as are also the polysynthetic grains, some of which may have been derived from schistose rocks. With the quartz grains are a few unmistakable particles of flint, but these are never numerous. Felspars and other minerals are usually rare. Sometimes the grains appear to be well rounded, and at other times they seem perfectly angular; but it is probable that in all cases a considerable amount of corrosion of the surfaces of the grains has taken place. Only in one or two doubtful cases have I seen what could be taken as a deposition of secondary silica upon, and in optical continuity with, the detrital quartz.

In a specimen from the valley of the Kennet (Enborne Lodge gravel-pit) we have perfectly angular quartz grains embedded in a nearly compact cement—one which can be resolved only under very high microscopic power.

A very remarkable variety of Sarsen is one from Staple-Fitzpaine, about 10 miles west of Taunton. In this rock the grains are much larger than in any other Sarsen that I have examined; they are markedly angular, and though quartz grains form a majority of the whole, yet felspars and other minerals occur much more usually than in the other specimens examined. If this should be found to be the rule with Sarsens from the most westerly localities, it would indicate that the granitic and metamorphic rocks which yielded the materials of which they are composed lay to the west of the London Basin.

[In a subsequent letter (February 27th, 1889) Professor Judd states that this "specimen from Staple-Fitzpaine has a fragment of whitened flint in it. The microscopic characters of which are unmistakably those of a silicified Chalk-mud full of fragments of Globigerina."]

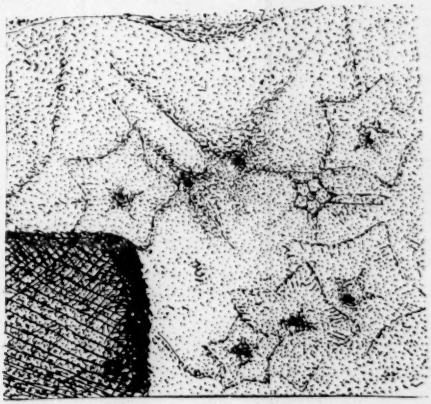
The cement of the flint-conglomerate of Hertfordshire consists of quartz grains, with a few grains of flint, embedded in a crypto-crystalline siliceous groundmass. There is no very striking resemblance between the cement of this conglomerate and that of any of the Sarsens which I have examined.

II.—Note on certain Impressions of Echinoderms observed on the Sandstone Slabs in which the Skeletons of *Hyperodapedon Gordoni* and *Rhynchosaurus* are preserved.

By Prof. Rudolf Burckhardt, Ph.D., of the University of Basel, Switzerland.

When searching for traces of the dermal structure preserved in the specimen of *Hyperodapedon* in the British Museum (Natural History) in London,[1] my attention was drawn to certain spots where the matrix showed projections and pits of a polygonal shape, which I detected when I took the photographs of this Triassic reptile. Primarily occupying myself with the matrix of the principal slab, in which the skeleton is enclosed, I quite thought I had only to deal with dermal structures similar to those discovered in *Rhynchosaurus*.

One of these spots, lying between the ninth and tenth ribs of the left side, particularly attracted my attention. This I was at first inclined to regard as a dermal ossification, the pentagonal character of which was unquestionable. On closer inspection I found, however, the whole of the matrix *densely covered with similar structures*, a circumstance which became still more perplexing in proportion as I discovered their immense numbers, which were equally abundant at a considerable distance from the body, and also in the matrix of the counterpart which had not been touched by the chisel. The matrix of the Rhynchosaurian fossils from Warwickshire also showed the same character; indeed, I found some on these slabs in even better condition of preservation.



Prints of Echinoderms in the Triassic Sandstones of Warwickshire and Elgin. From a specimen in the British Museum (Natural History). × 3.

Actual petrefactions they were not, but simply the hollow impressions leaving a film behind, between the coarse grains of the sand. In size they vary between 3 mm. and 3 cm. in diameter. The matrix is crowded with these bodies, which are deposited over each other, all of them lying in the same plane as the skeleton of

[1] See "On *Hyperodapedon Gordoni*": Geol. Mag., 1900, Nov. and Dec.

Hyperodapedon. Those facing the observer with their upper sides have left teat-like projections in the stone; others appear as funnel-shaped depressions made by a massive body.

In shape they are star-like pentagons, of about the same form as the bodies of Euryalidæ.

In diagonal opposition to the main portion of the star-shaped bed lies a small pentagonal plate consisting of five parts, which radiate from a central piece. I believe I have also detected some radiating striæ on the outer pentagon in a few exceptionally well-preserved examples, as well as some finer striæ, skirting the margin of the extreme pentagonal radially, where they arrange themselves in regular order. Besides these pentagons I noticed some series of smaller segments of about $\frac{1}{2}$ mm., which to the number of six unite with each other, though rarely more, in which latter case they are very difficult of detection.

The conclusions I have arrived at as to these structures, and to which I give expression quite reservedly to specialists engaged in this branch of geology, are as follows:—

These pentagonal forms are empty caverns left by Echinoderms of a Eurylaid shape, having peripheral arms, either simple or forked. To whatever group of Echinoderms they may belong will be a matter of investigation by specialists. Under no circumstances are they parts of *Hyperodapedon*. The two pentagonal sets of which they are composed, together with their projecting limbs, are forms which do not resemble any other type of the classes of invertebrates. In favour also of this inference is their enormous quantity and the great diversity in their sizes. The extreme delicacy of these impressions is probably the reason why my examination of the slabs did not yield a better result, as might have been the case if the stones had been more recently quarried or specially prepared for this purpose.

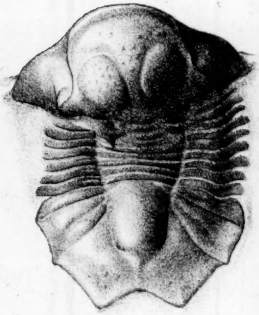
That no remains of their external skeletons are preserved, is in no way detrimental to this hypothesis, as a corollary to this is found in the case of those hollows left by Elgin reptiles, which E. T. Newton so admirably described from casts taken from their natural moulds. No other fossils having been found in these localities except reptiles, is also an argument in favour of such an interpretation as the above.

From a like presence of these casts in both localities, the Elgin sandstones, which Smith Woodward quotes as "supposed Trias," should be of the *same age* as the sandstones belonging to the Upper Triassic of Warwickshire and Shropshire.

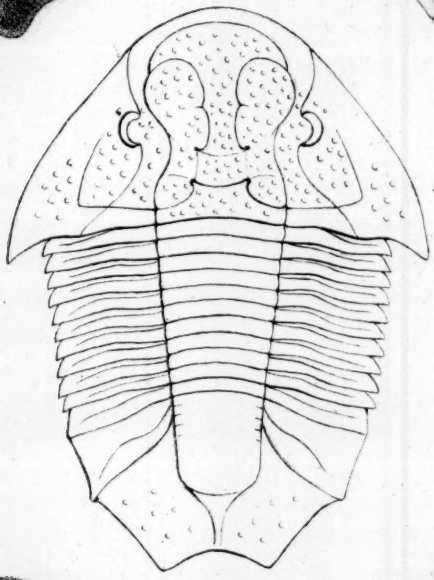
Interesting as may be the task of pursuing this highly attractive geological question, it is a matter of real regret that I am compelled to deny myself the pleasure of conducting the investigation of this subject further. I must confine myself here to the statement only, that I have good reason for believing that I have observed similar petrefactions of organic origin in some rather imperfect fragments from the Maleri deposits in India.

1 ×1½

3 ×2

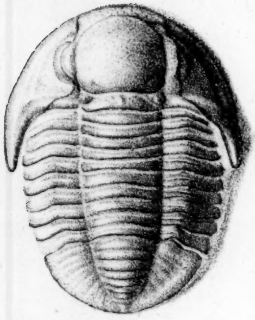


2 ×1½



4 ×2½

5 ×2



6 ×2

G.M.Woodward del.et lith. West, Newman imp.

Wenlock Limestone Trilobites.

III.—Woodwardian Museum Notes: Salter's Undescribed Species. II.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE I.)

Lichas scutalis, Salter. (Pl. I, Figs. 1–4.)

1873. *Lichas scutalis*, Salter MSS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 130 (*a* 954).
1877. *Lichas verrucosus*, Woodward: Cat. Brit. Foss. Crust., p. 43.
1878. *Lichas scutalis*, Edgell MSS.: Cat. Camb. Sil. Foss. Mus. Pract. Geol., p. 84.
1891. *Lichas verrucosus*, Woods: Cat. Type Foss. Woodw. Mus., p. 147.

THERE are three specimens of this species in the Woodwardian Museum, viz.: (1) Salter's fine original specimen (*a* 954) from the Wenlock Shale of Malvern, belonging to the first part of the Fletcher Collection, acquired prior to 1873; (2) a poor specimen probably from the same collection and horizon, locality unknown; and (3) an almost perfect specimen, also from the Wenlock Shale of Malvern, belonging to that part of the Fletcher Collection recently presented by Mrs. Fletcher. This specimen will be designated the Fletcher specimen in distinction to Salter's original specimen. Both these specimens show almost the whole trilobite preserved in excellent condition, and from them the following description has been drawn up.

Diagnosis.—*Head-shield* broadly parabolic, nearly twice as broad as long, and slightly produced backwards at genal angles; strongly convex from back to front and from side to side, slightly flattened between the eyes across the middle portion of the posterior half; anterior half of head-shield bent down very steeply to margin, almost at a right angle to posterior half; sides bent down as steeply in front, but less steeply towards genal angles, where they flatten out.

Glabella wide, occupying nearly whole middle third of head-shield; forms most elevated portion of head-shield, but is not swollen nor raised with independent convexity above fixed cheeks. Median lobe much expanded in front, its narrow laterally-projecting tongues overlapping anterior lateral lobes; constricted strongly at level of anterior lateral furrow, behind which it gradually decreases in width with nearly straight sides to the base of anterior lateral lobes, where it again expands a little. Behind this point the median lobe is only weakly marked off from the two pairs of posterior lateral lobes, but is traceable in the Fletcher specimen to the straight occipital furrow, where it has nearly double the width it possessed between the anterior lateral lobes.

Anterior lateral lobes large, of broadly oval shape, rather wider in front than behind, where the furrow which defines them is very faint. They extend about two-thirds the whole length of the glabella with their longer axes obliquely directed inwards, and with a gentle convexity of their own, bending down strongly in front with the median lobe and at the sides with the general curvature of the head-shield. In front they are separated from the

marginal furrow of the head-shield by the lateral projections of the median lobe.

Middle lateral lobes subquadrate in shape, small and indistinctly defined, being marked off in front from the anterior lobes by a very faint depression sweeping round the hinder end of the latter lobes and representing the middle lateral furrows. They are still more indistinctly marked off posteriorly from the basal lobes by weak grooves, while their outer sides are defined by the faint axal furrows and their inner sides by the continuation of the anterior lateral furrows to the occipital segment.

Basal lobes likewise weakly marked off from the rest of the glabella and fixed cheeks, but relatively large, being nearly the size of the middle lobes; subrhomboidal rather than triangular in shape, owing to the basal (posterior lateral) furrow starting, not from the level of the occipital furrow but a little way in advance of it. The posterior side of the basal lobes is marked off from the occipital segment by the strong deep occipital furrow.

Occipital ring flattened and very broad in the middle behind the straight portion of the occipital furrow at the base of the median lobe of the glabella, but with its lateral portions only about half the width, and bent backwards behind the basal lobes.

Axal furrows strongly marked only along the outer side of the anterior end of the anterior lateral lobes, being posteriorly very weak, as above mentioned. Behind the point where they pass into the marginal furrow which bounds the glabella in front they arch outwards, curving round inwards posteriorly as they define the anterior lateral lobes, to the base of which they nearly extend with a deeply impressed course. Here the middle lateral furrows pass imperceptibly into them. Behind this point the axal furrows become very weak, and curve outwards along the outer side of the middle and basal lobes to end in the occipital furrow.

Anterior lateral furrows arise far forwards, curving round the broad anterior end of the anterior lateral lobes, and then run with nearly a straight course backwards along the inner side of these lobes, slightly converging. At the posterior end of the latter each furrow bends a little outwards to end in a small pit from which the middle furrow starts. About half-way along the inner side of these anterior lobes there is a slight outward kink in these anterior furrows, from which a faint groove runs outwards a little distance across the lobe, such as has been noticed in *Lichas ornatus* (Angelin),[1] *Lichas anglicus* (Beyr.), and other species. Behind the pits at the base of the anterior lobes the anterior lateral furrows are traceable as faint slightly divergent grooves (especially clear in the Fletcher specimen), which finally meet the occipital furrow at the inner posterior angle of the basal lobes.

Middle lateral furrows weak and short, starting from the pit on the anterior furrows and curving round the base of the anterior lobes to merge imperceptibly into the stronger axal furrows.

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. ii (1885), p. 109, t. vi, fig. 18*a*.

Basal furrows extremely faint. As mentioned above, they are not straight lateral prolongations of the median portion of the occipital furrow, as is the case in many species, but they arise a short distance in front of it on the backward continuation of the anterior lateral furrow, and curve slightly forwards to join the axal furrow nearly at right angles.

In Salter's original specimen there is in addition to the above furrows a shallow transverse depression arched backwards, extending across the neck of the median lobe at the base of the anterior lateral lobes and between the pits on the anterior furrows. A similar transverse groove is seen in *Lichas palmatus* (Barr.), *L. scaber* (Beyr.),[1] and *L. anglicus* (Beyr.).

Occipital furrow composed of a central straight portion, not deeply impressed, and of lateral portions curving strongly backwards and strongly marked behind the basal lobes.

Fixed cheeks small, with an anterior wing forming a very narrow strip between the axal furrow and the facial suture. At the base of the anterior lateral lobes of the glabella, where the axal furrow bends in, the cheeks increase in width, expanding behind the eye and entering into the general convexity of the head-shield.

Eye-lobes of moderate size, prominent, horizontally-extended outwards on a level with the general convexity of the glabella, and situated just in front of the base of the anterior lateral lobes. A short furrow separates them from the fixed cheeks. In front of the glabella is a flattened horizontally-extended border of moderate width, widening a little laterally as it passes into that of the free cheeks, and marked off by a shallow marginal furrow.

Free cheeks triangular in shape, with an inner strongly convex portion abruptly elevated above the flattened broad border, and marked off behind by the occipital furrow and scarcely in front by the very weakly-defined marginal furrow which circumscribes its base and joins the occipital furrow at nearly a right angle. This inner convex portion of the free cheek bears the eye at its summit, but nearer the front than the anterior border.

Eye semicircular and prominent, rising up vertically with a high visual surface beneath the overhanging eye-lobe.

Border of free cheek flattened, rapidly increasing in width from the front to the genal angle, owing to the inward course of the marginal furrow. Genal angles slightly produced into blunt points.

Ornamentation.—The glabella, occipital ring, fixed cheeks, and the convex portion of the free cheeks are ornamented with tubercles of moderate size, rather sparingly distributed. On the flattened border of the free cheeks, particularly near the genal angles, there are also a few similar tubercles.

Thorax.—The thorax in the Fletcher specimen is nearly perfect and shows nine narrow segments, but in Salter's original specimen it is not so well preserved and only seven segments can be distinguished. In each case the specimen has its head and tail strongly bent upwards, and this has caused the body to break across at the

[1] Barrande: Syst. Silur. Bohem., vol. i (1851), pl. xxix, figs. 7 and 24.

junction of the head and thorax, forcing back the head over the first few segments of the body and concealing them. In the Fletcher specimen there are indications of one segment being thus covered, making the actual number of thoracic rings to be ten.

Axis of thorax gently convex, broad, tapering gradually to the pygidium, each ring consisting of a simple narrow band, apparently devoid of ornamentation. The anterior rings of the axis appear to be wider than the corresponding pleuræ, but the posterior ones to be narrower. Axal furrows weak.

Pleuræ semicylindrical, horizontally extended as far as the fulcrum, but then bent downwards, flattening again towards their extremities, which are separate and free. The fulcrum is distant from the axal furrow about one-third of the length of the pleura, and is obtusely rounded. Each pleura curves gently forwards to the fulcrum, then bends more strongly backwards, and again bends forward slightly towards its extremity. The surface of each pleura is marked along its inner portion by a nearly median furrow, which runs straight outwards to the fulcrum and then curves backwards over the outer portion to the point, dividing this outer portion into a flattened anterior and an elevated posterior part, but near the end the whole breadth of the pleura is flattened. The extremity is bluntly pointed. There are a few obscure traces of tubercles on the pleuræ.

Pygidium.—Broad and roughly pentagonal, gently convex from side to side, having its lateral lobes bent down, but flattened along its margin. Its component segments are closely fused together, and only the two anterior pleuræ on each side are marked out.

The pygidium is arched forwards in front; posteriorly it is forked, and each side is angulated by the projection of the extremities of the second pair of pleuræ.

The posterior margin lying in the fork is rather less than half the anterior width of the pygidium. The re-entrant angle is about 135°, and the sides meet the lateral borders at an angle of a little over 90° at the obtusely rounded divergent points of the fork. (In the Fletcher specimen these points are rather more acute.)

Axis cylindrical, convex, and prominent, being strongly raised above the lateral lobes. Its posterior end is pointed and prolonged to reach the posterior margin of the pygidium at the re-entrant angle, sloping down rapidly to the level of the flattened border. The cylindrical portion of the axis measures only about two-thirds the total length of the pygidium.

First axial ring only distinct, and marked off behind by a strong continuous furrow. Very obscure traces of four or five rings behind it. Axal furrows well marked on each side of the cylindrical portion, but very faint behind it and scarcely traceable to the margin.

Lateral lobes of pygidium, bent down on each side of the axis and consisting of a convex inner portion and a flattened marginal portion. Each lateral lobe measures anteriorly about $1\frac{1}{2}$ times the width of the axis.

First pair of pleuræ distinct, each pleura expanding outwardly to

double its axial width, and with a squarely truncated extremity, not projecting beyond the margin. A straight diagonal furrow marks the surface, but does not reach the extremity, and the outer anterior angle of the truncated end is flattened as in the pleuræ of the thorax, as if for rolling-up. The groove separating the first from the second pleura runs obliquely backwards and outwards at an angle of about 30° to the front margin of the pygidium, curving gently forwards at its outer end.

Second pair of pleuræ distinct, each pleura increasing rapidly to double the width possessed by the first pleura on the margin; end broad, truncated, and with posterior angle projecting beyond the margin as a distinct tooth; posteriorly marked off by weak furrow making an angle of about 45° with front margin of the pygidium. A median, slightly oblique furrow traverses the surface of the pleura, but stops short of the margin.

The position of the projecting ends of this second pair of pleuræ is about half-way along the lateral margins of the pygidium. Behind them the margin takes a slight curve inwards to the points of the posterior fork.

The lateral lobes behind the second pair of pleuræ show no segmentation or furrows, but probably are composed of two pairs of pleuræ, one ending at the lateral pointed extremities of the posterior margin and the other at the axal furrows in the re-entrant angle.

A few scattered tubercles are visible on the flattened marginal portion of the lateral lobes, especially near the posterior angles.

Measurements.

	I.	II.
	mm.	mm.
Length of head-shield	13·0 ...	11·5
Width of head-shield	26·0 ...	21·0
Length of glabella	11·0 ...	8·5
Width of glabella at front end	10·5 ...	10·0
Width of glabella at level of eyes	8·25 ...	7·5
Width of glabella at neck-furrow	9·0 ...	9·0
Width of thorax	about 22·0 ...	19·0
Width of axis of thorax	uncertain ...	8·0
Length of pygidium	11·5 ...	10·0
Width of pygidium at front end	18·0 ...	18·0
Width of pygidium between posterior angles	9·0 ...	8·0
Width of axis of pygidium	6·0 ...	6·0

I = Salter's specimen. II = Fletcher's specimen.

N.B.—In the Fletcher specimen the hypostome is also seen in its proper position on the lower surface of the upturned head. It is subpentagonal in shape; its length is less than its breadth, which is greatest across the middle. The central portion, which is also of greater breadth than length, is marked off by a continuous furrow from the border, is gently convex, and occupies about two-thirds of the whole length of the hypostome; its anterior end is strongly arched forwards, and its sides and posterior edge are nearly straight and parallel respectively to the lateral and posterior margins of the hypostome. A pair of faint short furrows run obliquely inwards from the lateral angles. The border is broad and flattened, extending

down the sides of the central portion from the lateral angles and round the posterior margin, where it is broadest and slightly excavated. The posterior angles are obtusely rounded.

MEASUREMENTS.

	mm.
Length of hypostome	7·0
Width of hypostome across middle	9·5
Length of central portion	5·0
Width of central portion	7·0
Width of posterior border	2·0

REMARKS.—To none of the other British species of *Lichas* from the Wenlock Series does *L. scutalis* show any close resemblance. *L. verrucosus* (Eichw.),[1] with which it has been confounded, belongs to a lower stratigraphical horizon, and differs in the following particulars,—the shape of the median lobe of the glabella, the form and size of the basal lobes, the course of the axal furrows, the position of the basal furrows, the course of the occipital furrow, the absence of a transverse groove across the median lobe of the glabella, the position of the eye and eye-lobes, the shape of the pygidium and the furrows on its lateral lobes, the shape of its axis, etc., etc. In fact, *L. verrucosus* is so utterly different from *L. scutalis* that it is surprising that they were ever considered identical or even closely allied. It is needless to enter into a minute comparison of the two species, as their specific separation is obvious.

Schmidt (loc. cit.) remarks that *L. scutalis* is quite distinct from *L. verrucosus* (Eichw.).

The species which shows most points of resemblance is Barrande's *L. ambiguus*[2] from Étage Ee2, which is more or less equivalent to our Wenlock. This species has a glabella with anterior lateral furrows continued down to the neck-furrow, with weak middle and basal furrows, and with axal furrows having the same general course and development as *L. scutalis*, though less curved inwards in the middle. The anterior lateral lobes are closely similar, even to the indentation on the inner side, but they are less oblique; the middle lobes are rather less distinct, and the basal lobes are only separable from them by their more swollen character. There is also a somewhat similar shallow depression across the neck of the median lobe. The smaller convexity of the head-shield and the greater parallelism of the sides of the glabella are points of difference. The occipital segment is also narrower, and the occipital furrow has a different course. The thorax of *L. ambiguus* is unknown. It is in the pygidium that we find the most striking points of resemblance: the shape of the axis and its continuation to the posterior margin, the presence of only two pairs of pleuræ on the lateral lobes with their furrows, the projection of the extremities of the second pair beyond the margin, the smooth unfurrowed posterior portion of the lateral lobes, the flattened margin, the

[1] Eichwald: Beitr. z. Kenntn. Russl., Bd. viii (1843), p. 63, t. iii, fig. 23. Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. ii (1885), p. 62, t. ii, figs. 1–11.

[2] Barrande: Syst. Silur. Bohem., vol. i (1851), p. 606, pl. xxviii, figs. 16–21.

posterior fork. The pygidium differs in being relatively narrower, in possessing a shorter axis with more rings, in the extremities of the first pleuræ projecting beyond the margin, and in the posterior margin being less deeply excavated.

PROETUS FLETCHERI, Salter. (Pl. I, Figs. 5 and 6.)

1873. *Proetus Fletcheri*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 134 (*a* 825, *a* 828).
1877. *Proetus Fletcheri*, Salter: Woodward, Cat. Brit. Foss. Crust., p. 56.
1891. *Proetus Fletcheri*, Salter: Woods, Cat. Type Foss. Woodw. Mus., p. 151.

This species, which is recorded by Salter (loc. cit.) from the Wenlock Limestone of Dudley, is mentioned by him after *Pr. latifrons* (McCoy) as "a broader species in all parts, more like *Pr. Ryckholti* (Barr.) than *Pr. latifrons* (McCoy)."

There are three specimens of *Pr. Fletcheri* in the Woodwardian Museum, which were labelled by Salter *a* 825 (2) and *a* 828, and are thus entered in his "Catalogue." But mounted on the same tablet are seven other unlabelled specimens of *Proetus*, of which only one belongs to this species, all the others showing points of difference. There are four other specimens of the true *Pr. Fletcheri* in the Woodwardian Museum, three of which are from the Fletcher Collection and the other from the Leckenby.

The specimens from which the following description is drawn up are those three labelled by Salter *a* 825 (2) and *a* 828.

DIAGNOSIS.—General shape longitudinally oval, more than twice as long as broad.

Head-shield broadly parabolic, about twice as wide as long, gently concave posteriorly, moderately convex from side to side, bent down in front. Genal angles produced into spines.

Glabella very broadly oval, as broad as long, more than one-third the width of the head-shield at base, narrowing slightly towards the obtusely rounded anterior end, which reaches the anterior border of the head-shield; gently convex from side to side, bent down steeply in front of eyes.[1] Surface marked by two pairs of furrows, but anterior pair generally obsolete. Basal pair of furrows short, weak, shallow; curve slightly backwards; situated at level of middle of eye and at more than one-third the length of glabella from neck-furrow. Anterior pair of furrows when present very weak, directed obliquely backwards from level of anterior end of eye.

In Salter's specimen *a* 825 (here figured Pl. I, Fig. 5) there is an additional pair of small pit-like impressions on the glabella, situated behind the basal furrows and close to the occipital furrow, and about half-way between the axal furrows and the median line of the glabella. I have not noticed them preserved in the other specimens, but they may be compared with somewhat similarly placed basal pits on the glabella of some specimens of *Pr. bohemicus* (Corda).[2]

[1] Owing to this strong downward bend of the front end of the glabella, the shape seems to be subcircular in Fig. 5.

[2] Barrande: Syst. Silur. Bohem., vol. i (1852), p. 452, pl. xvi, figs. 6, 7.

Axal furrows weak in front of the eye, and passing into the marginal furrow at the front end of the glabella. Between the eye-lobe and glabella, and posterior to the eye, they are deep and strong.

Occipital furrow stronger than axal furrows, and arched forward in the middle and at each side in front of the lateral occipital nodule.

Occipital ring rounded, considerably wider than a thoracic axial ring, and furnished with a small median tubercle and a pair of lateral nodules, which are sharply circumscribed, of oval shape, swollen, prominent, and occupying nearly the whole width of the occipital ring at the base of the axal furrows.

In front of the glabella is a raised and rounded border, well defined by a strong marginal furrow.

Fixed cheeks with narrow anterior wing and large, semicircular, horizontally-flattened eye-lobe, strongly elevated to nearly the height of glabella. Eye-lobes reach from anterior lateral furrows of glabella to behind basal pair, but do not project enough laterally to cover whole upper surface of convex eye. Posterior wing of fixed cheek small and triangular, owing to course of facial suture. Occipital segment of cheek rounded, raised, and narrower than occipital ring behind glabella.

Facial sutures cut anterior border of head-shield at a distance apart equal to basal width of glabella. From these points of section they curve backwards and slightly inwards to front of eye, then bend out and circumscribe eye-lobe, and behind it curve sharply outwards to cut neck-ring obliquely at an angle of 20°–30°, reaching the posterior margin close to the base of the genal spine.

Free cheeks triangular, furnished with broad, rounded, and striated border, continued backwards at the genal angle into the genal spine, which is broad at the base, tapers rather rapidly to its pointed extremity, and is less than half the length of the head-shield. It is ornamented with longitudinal striations. The marginal and occipital furrows meet each other at the genal angle at an angle of nearly 60°. The inner portion of the free cheeks is strongly elevated and convex, with steep anterior but gentler lateral and posterior slopes. On the summit it bears the large prominent eye which extends for nearly two-thirds the length of the glabella. A shallow groove encircles base of eye, and runs round it from the level of the occipital furrow to the anterior lateral furrow of the glabella.

Thorax about equal in length to head-shield, consisting of ten segments, with a broad, gradually tapering, cylindrical axis, nearly half as wide again as the pleural portions. Rings of axis simple, regular, and devoid of ornamentation. Axal furrows distinct, but not deeply impressed.

Pleuræ semicylindrical; each consisting of an inner, straight, horizontally-extended portion and an outer, longer, extra-fulcral portion, which is bent gently downwards and backwards at an angle of 45°. Inner portion crossed by diagonal furrow, making an angle of about 20° with the straight anterior edge. This furrow divides the inner portion into two unequal parts, of which the posterior is much the larger. On the extra-fulcral portion the furrow is obsolete, and

the anterior part of the pleura is flattened into an articulating surface which passes underneath the preceding pleura. Fulcrum well-marked and angular, at the junction of the inner and outer portions of the pleura. Extremities of pleuræ truncated and rounded.

Pygidium semicircular, about two-thirds the length of the thorax; with simple entire margin, and distinct raised border. The anterior edge of pygidium resembles that of a pleural ring, the inner part being short and straight and the outer part oblique with an articulating surface. Lateral and posterior margins incurved and concentrically striated below.

Axis conical, strongly elevated above the flattened lateral lobes, and tapering more rapidly than axis of thorax to an obtusely pointed extremity, reaching the marginal furrow inside the raised border. Seven to eight rings recognizable on axis, of which only the three first are clearly separated by strong intersegmental furrows, the posterior ones being more or less indistinct. Lateral lobes gently bent down on each side, and marked with three or four pleuræ with inner horizontal portion generally distinguishable, but devoid of fulcrum. A weak longitudinal furrow runs down the centre of each pleura.

Border of pygidium distinct and raised slightly above level of lateral lobes, narrower at anterior lateral angles and behind axis than in middle of sides. It is marked off by a shallow marginal groove, and in one specimen (*a* 825 of Salter's Catalogue) the pleuræ and their furrows are faintly traceable across it, but in some individuals it is very indistinct.

Ornamentation.—The whole surface of the head and pygidium is finely granulated.

Measurements.—Salter's specimen *a* 825 :—

	mm.
Length of whole trilobite	22·0
Length of head-shield	8·0
Length of thorax	8·0
Length of pygidium	6·0
Width of head-shield at base	15·5
Width of pygidium	10·5
Width of glabella at base	6·0

Remarks.—This species resembles *Pr. bohemicus*, Corda,[1] in the following particulars: (1) shape, relative size, and proportions of glabella; (2) presence of lateral nodules and median tubercle on occipital ring; (3) relative proportions of thoracic axis and pleuræ; (4) characters of pleuræ; (5) shape of pygidium, pygidial axis, and border; (6) granulated test.

Pr. bohemicus differs, however, in having a semicircular rather than parabolic head-shield, in possessing very short genal spines, smaller eyes and eye-lobes, and a relatively narrower border to the head-shield; in the presence of three pairs of lateral furrows on the glabella; in the greater length of the thorax; and in the smaller size

[1] Corda: Prodr. Böhm. Trilob. (1847), p. 73, pl. iv, fig. 43. Barrande: Syst. Silur. Bohem., vol. i (1852), p. 452, pl. xvi, figs. 1–15.

of the pygidial pleuræ. On the other hand, *Pr. Ryckholti* (Barr.),[1] to which Salter saw a resemblance, agrees in the shape of its head-shield, in the faintness of the lateral furrows of the glabella, in the size of the genal spines; in the median tubercle on the occipital ring; in the relative size of the eyes; and in the general aspect of the pygidium. But it differs in the shape and proportions of the glabella and of the thorax; in the absence of lateral occipital nodules; in the shape of the pleuræ; in the more rapidly tapering axis of the pygidium; and in the smooth test. *Pr. Fletcheri* shows, therefore, a much closer resemblance to *Pr. bohemicus* than to *Pr. Ryckholti*.

EXPLANATION OF PLATE I.

Fig. 1.—*Lichas scutalis*. Salter's original specimen, *a* 954; Wenlock Limestone, Malvern. × 1½.

Fig. 2.—*Lichas scutalis*. Fletcher Collection specimen; Wenlock Limestone, Malvern. × 1½.

Fig. 3.—*Lichas scutalis*. Hypostome of Fletcher Collection specimen. × 2.

Fig. 4.—*Lichas scutalis*. Outline restoration. × 2½.

Fig. 5.—*Proetus Fletcheri*. Salter's specimen, *a* 825; Wenlock Limestone, Dudley. × 2.

Fig. 6.—*Proetus Fletcheri*. Side view of same specimen.

Note.—The two figured specimens of *Lichas scutalis* are bent up at the head and tail, causing some foreshortening of these parts in the figures, and the ends of the pleuræ to be widely separated.

IV.—Note on the Preparation of Spherulites.

By Henry Bassett, Jun.

LAST February, while working in the Chemical Laboratory of University College, London, I had occasion to make some sulphanilic acid. This was done in the usual way by heating a mixture of 100 grammes of concentrated sulphuric acid and 30 grammes of aniline to 180°–190° C. in an oil bath for four hours. The flask containing the mixture was left in the oil bath to cool, and on examining it the next day I was surprised to find that the solid mass inside had developed a beautiful spherulitic structure. As I believe this has never been observed before, it may be worth a description.

In colour the material is a bluish (or sometimes greenish) grey, and it is practically a mass of spherulites, some of which are an inch in diameter. They are mostly well developed, and are slightly lighter in tint than any intervening portions of the mass in which a spherulitic structure is only faintly visible. They consist of concentric layers, alternately nearly white and pale blue in colour, with rather ragged edges, as may be seen in the figure. Adjacent spherulites, or sometimes even what are apparently simple ones, often exhibit sharp divisional planes like joints, from the one having grown up against another as they were developing from independent centres. Though these centres cannot in all cases be seen, there is sufficient evidence in others to justify applying this explanation to all. The mass, judging from the position of the spherulites, seems to have started crystallizing from a number of independent points, both on the surface of the glass and on the surface of the molten mixture.

[1] Barrande: Syst. Silur. Bohem., vol. i (1852), p. 439, pl. xv, figs. 15–19.

As pure sulphanilic acid is colourless the bluish-grey colour must be due to the production in the course of the reaction of a small quantity of impurity, which is of the nature of an aniline dye.

When we come to study the spherulites more closely we find that, not only do they exhibit an alternation of colour in concentric shells, but also that near the upper surface of the mass, as incomplete spherulites developed downwards these were prolonged as a kind of film on the surface of the glass above the solid mass, this film no doubt being originally caused by the adherence to the glass of a small quantity of liquid when the vessel was shaken. An examination of this thin section (as it were) of a spherulite shows that the pale bands in the solid mass are continued on the surface of the glass as bands of closely packed crystals, while the dark bands coincide with the bands on the glass where there are very

Photograph of the bottom of a flask containing the spherulitic structure.

few crystals. It is thus quite obvious that the alternate dark and light rings of the spherulites have been caused by a zoning out of the sulphanilic acid, the interstices having been filled up by the blue, very viscous magma (for only about 40 per cent. of the mass is sulphanilic acid, the rest being chiefly sulphuric acid). On this supposition the rings would be formed as follows: — A ring of radiating crystals would first be formed round some nucleus, but as the surrounding magma would thus be deprived of most of the sulphanilic acid it contained in solution, this ring would be succeeded by a ring where there were very few crystals, then another ring with a great many crystals would follow, and so on. The formation of these spherulites would thus be very analogous to the formation of 'Napoleonite' and spheroidal granites, to take extreme cases,

while even spherulites in glassy igneous rocks often show similar colour-banding. This zoning out of the sulphanilic acid accounts for the ragged edges of the rings, while the existence of a hollow at the top of the mass where the spherical surface of the spherulites can be seen also points to the liquid magma having thus been soaked up.

I have since several times repeated the experiment, and find that the spherulitic structure is developed every time, provided that the liquid is allowed to cool slowly, although even when cooled quickly one or two may be formed. The size of the spherulites obtained varies greatly; on one occasion I prepared one which was two inches in diameter, but, as is so often the case in nature, the moderate-sized ones are generally the prettiest. Sometimes, after having left the flask to cool, I found next day that the material had not all solidified, but that there was a floating crust with spherulites growing downwards and also a solid layer at the bottom with spherulites growing upwards, thus confirming the opinion as to independent development from the two surfaces which I had formed from the examination of the first batch obtained. I should add, however, that the spherulitic structure is not always developed on the free surface of the mass, nor have I been able to prepare again the spherulitic films (if I may so call them) on the sides of the flask. The time taken for the mass to crystallize completely varies from one to three days, depending, I imagine, on the amount of impurity present. When the crystallization takes place very slowly it is very beautiful to watch the small spherulites gradually growing in a dark, almost black, magma, until finally it is completely transformed into spherulites. In this intermediate state the specimen looks very much like spherulitic obsidian.

When the spherulites are formed very slowly the zones, which are so noticeable in specimens which have formed more quickly, are not nearly so frequent or well-marked. This perhaps is due to the fact that, as the crystallization is so slow, diffusion is able to prevent the magma round the centres of crystallization becoming exhausted.

I may add that the sulphuric acid present renders the mass very deliquescent, so that in order to preserve it the flask containing it should be sealed off in the blowpipe flame.

After about two months' keeping the mass begins to recrystallize, and, in course of time, the original structure is entirely obliterated and replaced by an immense number of small spherulites about 1 mm. in diameter. This molecular change is curious, but the fact that not even the external form of the original spherulites is preserved, is probably due to the presence of fluid, which, when recrystallization took place, was able to escape and collect at the bottom of the flask.

My thanks are due to Mr. Coomára-Swámy for having very kindly photographed the structure for me. This figure, however, does not represent the best specimen, for the shape of the vessel in which that had been formed was unfortunately unsuitable for photographing.

V.—The Sources and Distribution of the Far-Travelled Boulders of East Yorkshire.

By J. W. Stather, F.G.S.

ABOUT ten years ago, when studying the drifts of East Yorkshire, Mr. G. W. Lamplugh counted and roughly classified the larger boulders of Flamborough Head and other selected localities on the coast. This work has been continued by members of the Hull Geological Society, who have up to the present time recorded nearly four thousand boulders, of twelve inches and upwards in diameter. To avoid possible error, arising from the moving beach and other causes, only the boulders actually in place in the clay were noted, or such as had obviously recently fallen from the cliffs. The whole of the coastline from Spurn to Flamborough has been surveyed in this way, and also portions of the coast north of Flamborough as far as Saltburn. The lists thus prepared have been published from time to time by the Hull Geological Society and by the Erratic Blocks Committee of the British Association.

These lists bring to light several interesting and previously unnoticed facts with regard to the distribution of the far-travelled boulders, especially when the lists obtained at Dimlington and Redcliff in South Yorkshire are compared with the lists from Upgang and Saltburn in the north. Before, however, discussing the statistics of the boulders, it will be advisable to give a brief description of the localities where the lists were compiled.

(i) Dimlington is situated on the sea-coast near the southern extremity of Holderness. The cliffs average about eighty feet in height for upwards of two miles, and are entirely composed of glacial material, chiefly boulder-clay. Here were noted 334 boulders of twelve inches and upwards in diameter.[1]

(ii) Redcliff is on the north shore of the Humber, near North Ferriby, and is twenty-four miles west-north-west of Dimlington. The cliff continues along the Humber side for two-thirds of a mile with an average height of eighteen feet, and together with the adjacent beach is composed of boulder-clay. The boulders recorded here were 373 in number.[2]

(iii) Upgang is one and a half miles north of Whitby; the cliff sections are one hundred feet or more in height, and consist largely of boulder-clay. In this neighbourhood Mr. Lamplugh counted and classified two hundred boulders of twelve inches and upwards in diameter, the majority of which were of local origin; the percentages given in the table below are based on his list.[3]

(iv) The cliffs between Saltburn and Redcar present the most northern exposure of boulder-clay on the Yorkshire coast. These sections yielded 133 boulders of twelve inches and upwards in diameter.[4]

[1] Trans. Hull Geol. Soc., vol. iii, p. 6.
[2] Proc. Yorkshire Geol. and Polytech. Soc., vol. xiii, pt. 2, p. 211.
[3] Ibid., vol. xi, pt. 3, p. 403.
[4] Trans. Hull Geol. Soc., vol. iii, p. 7.

After eliminating all the *local* boulders from the lists, at the above-mentioned localities, the relative proportion between the several groups of *far-travelled* boulders is as follows :—

Groups.	I. Dimlington.	II. Redcliff.	III. Upgang.	IV. Saltburn.
	per cent.	per cent.	per cent.	per cent.
1. Carboniferous limestones and sandstones	55	59	70	73
2. Basalt (Whin Sill)	32	30	24	20
3. Magnesian limestone ...	0	0	5	7
4. Granite, gneiss, etc.	13	11	1	0 [1]
	100	100	100	100

It will be seen from the above table that among the far-travelled boulders of the East Yorkshire drift deposits, Carboniferous rocks (group 1) take numerically the leading position ; and the Carboniferous area west and north of the Tees is generally regarded as their place of origin. Group 2 consists of boulders of black basalt, very plentiful in East Yorkshire and very easy to distinguish. The source of these basalts is undoubtedly the Whin Sill. It is clear, then, that groups 1 and 2 have travelled into our district from practically the same area; nevertheless, it will be seen, on referring to the above table, that the relative proportions of the boulders from the two groups vary considerably from point to point. Thus, while both groups probably decrease *numerically* southwards, the percentages show that the basaltic group increases *relatively* from Saltburn southwards. The obvious explanation seems to be that large boulders of basalt bear transport better than similar masses from the Carboniferous sedimentary rocks.

The Magnesian limestone (group 3) occurring in the East Yorkshire boulder-clays is matched by the rock found *in situ* at Roker, near Sunderland. This limestone is rarely found except as pebbles in South Holderness, but these grow perceptibly in numbers and size northwards. Large boulders begin to appear north of Scarborough, and at Whitby and Saltburn they form from 5 to 7 per cent. of the foreign boulders present in the clays.

Besides the above-mentioned rocks, the East Yorkshire drifts, especially in the southern parts of Holderness, are rich in boulders of igneous rocks of widely diverse types, and these are included in group 4. Phillips long ago pointed out that in the drifts of the Yorkshire coast there were rocks from the English Lake District; and it is now certain also that the Cheviots and Scandinavia are well represented; but the source of by far the greater number of the rocks included in this group is not yet known. The table shows that the boulders of group 4 diminish both numerically and

[1] This group was not represented by any boulders of the requisite size in the cliff sections when this table was compiled, but several large boulders of Shap granite were seen in the gardens and about the town, which had probably been derived from the neighbouring drifts.

proportionately northwards, the figures being 13 per cent. at Dimlington and 1 per cent. at Whitby. This northward decrease of the group as a whole is all the more noteworthy when we remember that the Shap granites and the Cheviot porphyrites, both included in group 4, increase rapidly in the same direction. This seeming anomaly arises, I think, from the influence of the boulders from Scandinavia. Among the boulders of South Holderness occur very commonly rocks which agree with certain well-known types of Scandinavia; of these the best known are the augite-syenite (laurvikite) and the rhomb-porphyry. These types, although not by any means unknown in the drifts of North Yorkshire, are much rarer there than in the south. For instance, at Dimlington one hundred specimens of the Scandinavian rocks above named would be found to one of Shap granite, while, on the other hand, at Robin Hood's Bay or Runswick Bay (both near Whitby) the Shaps outnumber the Norsemen by at least twenty to one. Seeing, then, that the known Scandinavian rocks in group 4 are much more common in the south of the county than in the north, and that the distribution of the unidentified rock types included in the same group agrees in this respect with the Scandinavian rocks, I think it may be fairly inferred, that these unidentified rocks are probably largely from Scandinavia also.

Mr. Harker arrived at a similar conclusion when examining Mr. Lamplugh's Flamborough specimens.[1] He regarded the bulk of the granitic and gneissic specimens as having been derived either from Scandinavia or from the Scottish Highlands, and remarks: "Among these are some undoubted Norwegian rocks, while none can be pointed out as certainly brought from Scotland. It may be, then, that the whole of the doubtful rocks are also of Norwegian origin."

It is worthy of note with regard to the smaller boulders and pebbles of the boulder-clay and gravels of East Yorkshire that among these the percentage of the far-travelled rocks is much higher than among the larger boulders. There are certain types also among the smaller specimens which seldom appear as large boulders. Among these is a fairly definite group of rocks, which are known among East Yorkshire collectors as *porphyrites*, and are referred with some confidence to the Cheviot Hills. The evidence in support of this conclusion may be briefly stated as follows:—(1) The erratics seem to match the descriptions of the Cheviot rocks published by Mr. J. J. H. Teall and others. (2) Pebbles of these rocks increase, both in numbers and in size, as we approach the Cheviot district. (3) During a recent excursion (July, 1900) to the Cheviot Hills, arranged by the Yorkshire Geological and Polytechnic Society, many rocks similar to these East Yorkshire erratics were seen in place.

There is still another note to be made with regard to the Cheviot boulders, and that refers to their vertical distribution. I think it will be found, that the Cheviot rocks are more plentiful in the

[1] Proc. Yorkshire Geol. and Polytech. Soc., vol. xi, pt. 3, p. 409.

upper clays along our coast than in the lower beds. But however this may be, it is quite certain that the somewhat scanty drift that reaches farthest up the valleys on our coast, and climbs the eastern flank of the Yorkshire wolds, and the Oolitic moorlands, is, as far as the foreign boulders are concerned, composed almost entirely of rocks from the Cheviot area. The Scarborough district supplies a good example of this rule. The comparatively low ground adjacent to the sea is covered with thick drift full of boulders of the usual types. On the other hand, Seamer Moor, which is a mile and a half west of the town and six hundred feet in height, is capped by drift, the foreign pebbles of which are largely porphyrites. It must not be understood from this, however, that other types are entirely absent at high levels. Occasional specimens from probably all the groups are found wherever the drifts extend. But the rule is, that at high levels and along the western margin of the drift generally, the porphyrites prevail. And if we follow that very ill-defined line which separates the drift areas from the driftless, it will be generally found that the outermost fringe of straggling pebbles on the fields is largely composed of porphyrites.

All the facts respecting the distribution of the boulders of East Yorkshire, as far as I have seen, appear to agree with the supposition put forward by Mr. Lamplugh in his paper on the drifts of Flamborough Head,[1] viz., that the North Sea ice-sheet attained its maximum development and reached farthest inland before the ice flowing from the north-west had reached this part of the coast, and that the North Sea ice dwindled away as the flow from the Pennine Chain and the Cheviots gained strength.

VI.—On the Formation of Reef Knolls.[2]

By R. H. Tiddeman, M.A., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

At the meeting of the British Association at Newcastle in 1889 I brought out my interpretation of the probable origin of the limestone knolls of Yorkshire.[3]

It was shown that the Lower Carboniferous Rocks in the North of England had two distinct types—that the Yoredale or Northern type extended from the Craven Faults to the Tyne, and that the Southern or Bowland type occupied the country from the Craven Faults to near the Western Seaside plain and extended south as far as Derbyshire. Without now recalling the two tables of the succession there given, I mentioned specially the curious construction of certain mounds of limestone which I called reef-knolls, gave my reasons for supposing that they had been gradually built up on a slowly sinking sea bottom by the gradual accretion of animal remains somewhat in a similar manner to coral reefs. I also showed that from the enormously disproportionate thickness of rocks in the

[1] Q.J.G.S., vol. xlvii, p. 428.

[2] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

[3] Report Brit. Assoc., 1889.

area of the downthrow side and from other considerations there was every reason to suppose that the Craven Faults were actually taking place during the formation of those rocks.

My friend Mr. J. E. Marr, F.R.S., has in a most courteous way, whilst taking my geological mapping as for the most part correct, found reasons for dissenting from all the groundwork on which it was founded.[1] In combating Mr. Marr's views I offer no opinion on knolls of other localities or other ages which he brings forward in support of his views. I speak only of the Carboniferous knolls of which I have written, and with which I am well acquainted. Speaking generally, I think the differences between us may be thus summarized:—

1. Mr. Marr disagrees with my reading of the succession and thickness of the rocks on the south side of the Craven Faults, and, whilst I consider that we have two distinct successions of different thickness caused by a difference in the rate of submergence in the two districts, and by shallower and deeper seas, he regards the rocks on both sides as having been one series of like thickness in orderly sequence to the north, but, so to speak, shuffled by earth-movements on the south of those faults and repeated several times by overthrusts.

1*a*. In illustration let us take a pack of cards, say arranged in suits as representing the regular country on the north side, and several packs similarly arranged to represent the greater thickness on the south side. Shuffle these last to represent the supposed disturbance and overthrusting. Shall we always find after shuffling the same general succession? Yet over a tract reaching from Draughton to Chipping and from Settle to Derbyshire, we do get such a general succession, and that does not at all resemble the succession on the north side of the faults. The overthrusting to do this effectually must cover the whole of this wide area comprised in three or four counties, and not confine its operations to a narrow disturbed belt near the Craven Faults. Is Mr. Marr prepared to make his orogenic movements extend over so large an area, and thereby arrange the whole country, which they break up, into so orderly a disposition?

2. Mr. Marr regards the great difference between the black and white limestone, the form and constitution of the reef-knolls, the abundance in them of perfect fossil forms in a well-preserved state, the conglomerates and breccias which accompany them, as all being the result of what he calls orogenic movements; in other words, of the folding repetition and overthrusting of the rocks, with here and there *relief of pressure*. More especially is the last called in as being the reason for the abundant and well-preserved fossils and the change of the limestones.

It is extremely difficult for me to accept these views. If we could believe that a black, well and thinly bedded limestone can by any physical change be converted into a white crystalline mass with

[1] Quart. Journ. Geol. Soc., vol. lv, pp. 327–361.

little visible bedding, but with abundant fossils in a perfect state, we have still to learn what has become of the shales which are almost always present with the black limestone. If squeezed out, as might be suggested, they would at least leave partings behind, and the rock would be more bedded than it is.

Mr. Marr contemplates the likelihood of several different limestones being shifted together to make one reef-knoll, but if so, are we not as likely to get the thin sandstones of the Pendleside Grit sandwiched into them as well? Yet sandstones and shale-beds are unknown in the reef-knolls.

Mr. Marr makes a number of statements about what he calls the Vs of the Middle Craven Fault. His opinion is that this is a great thrust-plane dipping gently north, and that the Coal-measures are forced beneath the limestone, and so on along its course. A bed of coal in the limestone at Ingleton is regarded by him as having been forced up from underlying Coal-measures by pressure, and not as originally interbedded. Unfortunately for these views, there are no proper Vs or dipping planes of faulting indicated in the map. The sinuous track of the Craven Fault is not so drawn to accommodate any theory, but is merely put where the exposures of rock show it to run. Its wanderings are either dictated by or stand in relation to the two principal lines of jointing in the limestone, which range W.N.W. and N.N.W. Sometimes one direction, sometimes the other, has the mastery. At Clapham the line is absolutely straight, and does not curve up-stream as suggested by Mr. Marr. The coal-seam mentioned is well known to me. On searching it I found several *Producti*, fairly perfect, embedded in it and filled with it, and the conclusion I came to was that it was either a coal-seam which had grown on a reef and been submerged, or a deposit of seaweed. These *Producti* seem to disagree with the injection theory. Such coal-seams are found occasionally in the limestone. One near Kirkby Lonsdale has been worked for coal.

Mr. Marr has mentioned two places where knolls of grit occur. I do not admit that a knoll of grit can have anything in common with the reef-knolls of Craven unless it be the external form; but if such structures were made by earth thrusts and abounded, it would no doubt be a strong point in favour of his views. One of these grit knolls is said to be in the canal at the back of Shipton Castle. I think this must be an error. I know of no sandstone in that locality, though I know it well. I have consulted others who are, as geologists, conversant with Shipton, competent to form an opinion, and they agree with me that nothing but limestone and shales occur in that canal at that point. The beds there are certainly contorted, but they are not sandstone, and contortions do not necessarily imply reef-knolls.

I feel unable to regard Mr. Marr's 'model knoll' as in any respect resembling what I have called reef-knolls. That is, according to his views, a broken plication of a thin hard bed of limestone in a mass of softer shale, the shale surrounding its broken fragments. The knolls to which I allude are almost solid limestone from top to base.

They have no alternations of hard and soft beds, and, so far as I have seen, no repetition of beds by folding. The evidences of movement on their flanks, if any, are not more than one would expect from the vertical pressure of a more or less plastic shale upon what is at least a less plastic limestone.

I admit fully that there are abundant evidences in the district of faulting, of great pressure, and quite likely of overthrusts; but to say that these have given to these rocks a change of character, or are responsible for the order of their succession, appears to me to be invoking an unnecessarily powerful but yet inadequate force. Such thrust-planes as are implied would meet the geologist in the field at every turn, and force themselves into recognition. They would admit of easy mapping, and no statement of their existence would be complete without some such systematic recognition.

NOTICES OF MEMOIRS.

I.—On some Recent Geological Discoveries in the Nile Valley and Libyan Desert.[1] By Hugh J. L. Beadnell, F.G.S., F.R.G.S.

In this paper the author draws attention to some interesting discoveries made by him during the last three or four years while attached to the Geological Survey of Egypt. When the latter Survey was established in 1896 the publications and maps, both geological and geographical, of the Rohlfs Expedition of 1873–74 still remained the only source of information on the greater part of Egypt.

In his geological reports Zittel, the geologist of the Rohlfs Expedition, calls special attention to the absence of any unconformity between the Cretaceous and Eocene deposits, in fact mentioning this as one of the most important results obtained. More extended researches have, however, enabled the author "to bring forward incontestable evidence from at least two areas in the Libyan Desert, namely, Abu-Roash, near Cairo, and Baharia Oasis, that instead of this perfectly gradual petrographical and palæontological passage, undisturbed by any unconformity, from the uppermost marine Chalk into the oldest Tertiary beds, there is as a matter of fact a strongly marked unconformity, representing a long lapse of time in the process of sedimentation. During this period the Cretaceous was elevated into land, often with intense folding and faulting, and underwent considerable denudation before subsidence led to the entire or partial submergence of the area below the sea, and allowed the deposition of successive beds of Eocene in a markedly overlapping manner."

The accompanying table is compiled chiefly from the work of Professor Zittel and the Geological Survey of Egypt.

[1] Abstract of a paper read (with the permission of Captain H. G. Lyons, R.E., F.G.S., the Director-General of the Egyptian Geological Survey) before the International Geological Congress at Paris, 1900.

TABLE OF THE EOCENE AND CRETACEOUS SERIES IN THE LIBYAN DESERT AND NILE VALLEY.

EOCENE.	**Bartonian.**	Upper Eocene of Siwa Oasis, with *Nummulites Fichteli, N. intermedia, N. Rutimeyeri*, and *Orbitoides papyracea.*			
	Parisian.	Upper Mokattam. Lower Mokattam, with *Nummulites Gizehensis* limestones.			
	Londinian. **Suessonian.** **Flandrian.**	Upper Libyan. *Callianassa* beds, *Alveolina* limestones, etc. Lower Libyan. Limestones with *Operculina libyca, Lucina Thebaica, Nautilus Forbesii*, etc. Esna Shales (of Qena, Farafra, Kharga, etc.).			
CRETACEOUS.		Abu-Roash.	Baharia Oasis.	Dakhla Oasis.	Nile Valley.
	Danian.	White Chalk with corals, *Ostrea, Spondylus, Rudistes*, etc.	White Chalk with corals, *Gryphæa vesicularis, Exogyra Overwegi, Pecten Farafrensis, Corax pristodontus*, etc.	White Chalk with corals. *Ventriculites, Ananchytes ovata, Gryphæa vesicularis, Pecten Farafrensis*, etc. Greenish and ash-grey leafy clays.	White chalky limestones.
	Senonian. **Campanian.**	Part of White Chalk? Marls and limestones with *Tissotia Tissoti, Ostrea Costei, O. dichotoma*, etc.; *Echinobrissus Waltheri.*	Probably some of the intermediate beds are Senonian or Turonian.	Bone-beds.	Beds with *Trigonoarca multidentata, Ptychoceras.*
	Senonian. **Santonian.**	Marls with *Plicatula Ferryi.* Flinty limestones.			Bone-beds.
	Turonian.	Limestones with *Nerinæa Requieniana, Acteonella (Trochacteon) Salamonis, Biradiolites cornu-pastoris, Millestroma Nicholsoni.*		Nubian clays and sandstones.	Nubian clays and sandstones.
	Cenomanian.	Limestones with *Cyphosoma Abbatei, Hemiaster roachensis, Sphærulites, Radiolites*, etc. Clays and sandstones.	Limestones and variegated sandstones with *Hemiaster roachensis, Heterodiadema libycum, Neobolites Vibrayeanus.* Sandstones and clays with *N. Vybrayeanus, Exogyra flabellata, E. Mermeti*, and *E. olisoponensis.*		

The author then discusses separately several typical localities, which may be briefly alluded to.

Abu-Roash.—This peculiarly interesting Cretaceous complex, near Cairo, has been described by Walther and Schweinfurth as having been brought into position among the Eocene deposits by faults along its four sides. This view, however, is strongly opposed by the author, who maintains that the fault theory is absolutely untenable, "as a most casual examination of the boundary of the Cretaceous, at almost any point where its junction with the Eocene was visible, instead of suggesting the existence of faults, yielded indubitable evidence of their absence, and the presence instead of a well-marked unconformity." At some points "the upper surface of the white chalk of the Cretaceous shows a most irregularly eroded surface, which is covered by a bed of rolled pebbles, sometimes a metre thick, the latter being overlaid by a thick bed of Eocene shelly limestone, followed by a series full of characteristic Upper Mokattam fossils." The author further points out the existence in this area of Danian beds, the uppermost member (White Chalk) being apparently homotaxial with the White Chalk of Baharia and Farafra.

Baharia Oasis.—Of the remarkable sand belt which occurs between the Nile Valley and this oasis, the author says:—"This sand belt has a total breadth of five kilometres, and runs slightly west of north and east of south (parallel, in fact, to the normal direction of the wind). Its origin is much further north, probably in the neighbourhood of the oasis of Moghara, while to the south it runs, as far as known unbroken, into the depression of Kharga, whence, after a slight break, it continues southwards. Its length is thus certainly over 350 kilometres. The dunes are composed of light-yellow, siliceous, well-rounded sand-grains. The steepest sides are those facing west, which have an angle of 30°–31°. It is a remarkable sight, this narrow band of sand dunes extending across the open desert as far as the eye can reach, maintaining an almost exactly straight course, an even breadth, and with sides as well defined as if drawn with the edge of a ruler."

The author's work shows that, contrary to original ideas, there is in reality a remarkable development of Cretaceous rocks in the oasis of Baharia and the surrounding desert on the west and south sides.

The lowest beds, consisting of sandstones, clays, and marls, attain a thickness of 170 metres, and are of Cenomanian age. Above them come limestones and variegated sandstones (45 metres), followed by white chalk of Danian age, 40 metres thick. (See Table.)

As at Abu-Roash, the junction between the Cretaceous and Eocene is unconformable, the deposits of the latter overlapping successively the different beds of the former.

The author, in discussing the age and origin of the peculiar ferruginous quartzites which so constantly cap the numerous isolated hills within the depression, brings forward evidence which tends to show that these "were deposited in a lake which formed

here when there existed only a slight depression in the Eocene and Cretaceous rocks, ages in fact before erosion had carved out the depression to its present form. The large amount of ferruginous material and general character of the beds point to freshwater lacustrine deposition and precipitation. Lithologically they are often exactly similar to the Oligocene beds of the Fayum and Jebel Ahmar, and to the deposits on the road between Feshn and the oasis, and it may be that they are of the same age."

The author states that the igneous rocks of Baharia are of Post-Cretaceous, probably Oligocene, age, contemporaneous with the basalt sheets of the Fayum, of Abu-Roash and the desert to the west, and of Abu-Zabel; and that the andesites of the Libyan desert at Bahnessa, Gara Soda, and Jebel Gebail were likewise erupted at the same time.

After describing the important folds which occur in Baharia the author continues:—"The Cretaceous beds as a whole evidently form a large anticline . . . . which has its axis more or less parallel to the syncline already described. It is continued into the north end of Farafra, where the dip is well marked . . . . Yet the Eocene beds forming the plateau are in general quite horizontal, even in close proximity to inclined Cretaceous beds . . . . it seems certain that the Cretaceous beds, after the deposition of the White Chalk of Danian age, underwent upheaval, denudation, and finally depression, before the deposition of the earliest Tertiary beds.

"In this part of Egypt it appears that the subsiding Cretaceous land had the form of a long, flat, irregular ridge of anticlinal structure, extending from Dakhla oasis through Farafra, Baharia, and Abu-Roash. The northern end of this ridge was the last to subside and receive Eocene deposits, which accounts for the fact that in Farafra the Cretaceous is overlaid, always unconformably, by the Esna Shales of the Lower Libyan, in Baharia by limestones of the Upper Libyan, and at Abu-Roash by still younger beds of Lower and Upper Mokattam age."

The author finds other evidence which "suggests the probability that there was another period of possibly even more important earth-movements in Post-Eocene times. In this case, it seems not unlikely that the folding was closely connected with the important series of earth-movements which took place in North-East Africa and South-West Asia in early Pliocene times, and which gave rise to the formation of the chief topographical features of the country, such as the Nile and Jordan valleys and their attendant series of lakes."

The author's theory as to the origin of these wonderful depressions in the Libyan desert is interesting, and may be quoted in full. He writes:—"Baharia is a self-contained depression without drainage outlet, so that the ordinary methods of removal of disintegrated material do not here apply. Next, we have a large, flat, anticlinal ridge of Cretaceous beds, with at least one subsidiary, sharp, parallel, synclinal fold, overlaid by more or less horizontal beds of Eocene limestone. Since the elevation of this part of North Africa into dry

land in late Tertiary times, denudation must have gone on continuously over the whole surface of the country.

"The most important denuding agent at the present day in the Libyan desert is wind-borne sand, the erosive action of which is very powerful and at once apparent to every traveller in these regions; but in the past there may have been, and probably were, other eroding agencies as well at work on the surface of this part of North Africa. Imagine, then, the general planing down of the country little by little through a long interval of time, until the anticlinal ridge of Cretaceous beds was reached, with its attendant soft sandstones and clays. As soon as the latter were exposed the action of denudation would have rapidly quickened, chiefly by the breaking up of the constituents of these beds by changes of temperature, rains and frosts, and the removal of the resulting sand and dust by wind. In this way must these wonderful depressions have been formed.

"Generalizing, then, we may say that where there have been extensive deposits of soft beds, and these have become exposed by the action of denudation, there large depressions have been cut out. The existence of soft Cenomanian sandstones and clays is thus the primary cause of the existence of the depression of Baharia, the soft Esna shales have played a similar role in that of Farafra, while, again, Dakhla is cut out in a thick series of soft beds of Danian age. The other oases and depressions probably owe their existence largely to the same cause."

Farafra and Dakhla Oasis.—In Farafra the author's chief additions to our knowledge were rather geographical than geological, although some evidence is brought forward to show that the very fossiliferous clays on the road between Farafra and Dakhla are somewhat younger than the age assigned to them by Zittel.

In Dakhla oasis thick and extensive highly phosphatic bone-beds of considerable commercial value were discovered.

Fayum.—It was in this province that there existed, some 2,000 years before Herodotus, the celebrated Lake Moeris, the exact site of which has led to so much discussion. The author shows that the geological evidence, in the shape of clays with numerous fresh-water shells and fish-remains, of the same species as those at present inhabiting the existing lake, proves that the ancient lake occupied the lowest part of the depression, i.e. that now occupied by the Birket el Qurun and a considerable area of the low surrounding country. His position, in fact, closely agrees with that assigned to the lake by Major Brown, who bases his conclusions chiefly on considerations of level.

An extensive series of fluvio-marine beds, with intercalated sheets of basalt near the top, is shown to overlie the Upper Mokattam formation throughout the north part of the Fayum. This series is provisionally regarded as Oligocene. At the top come the silicified, wood-bearing sandstones, which stretch northwards across the desert to beyond the latitude of Cairo.

Within the Fayum depression, high up on the slopes or summits

of the surrounding ridges, are found extensive raised beaches, probably of marine Pliocene age, at which time the sea stretched far up the Nile Valley.

Nile Valley.—In conclusion, some highly interesting facts are brought forward with regard to the Nile Valley itself, which the author summarizes as follows:—"The general north and south direction of the Nile Valley in Egypt, the remarkable high, lofty, wall-like cliffs by which it is hemmed in, the absence of any true river deposits at any considerable height above the river, the almost entire absence of hills or outliers of the plateau within the valley, the proved existence of bounding faults throughout a long stretch of the valley, lead us to infer that the formation of this gorge was brought about by faulting, rifting, and folding, and not cut out in the usual way by river action."

Between Cairo and Assuan the Nile Valley floor is covered for the most part with deposits of comparatively recent geological age, which may be divided into (1) Marine, Pliocene; (2) Lacustrine, Pleistocene; and (3) Fluviatile, Recent.

The marine Pliocene deposits, discovered near Esna by Mr. Barron and the author in 1897, consist of a thick series of limestones and interbedded conglomerates. In the limestones numerous foraminifera were found, and have been described by Mr. F. Chapman.

The lacustrine series consist of fresh-water deposits of the most variable nature, including gravels, conglomerates, clays, marls, limestones, and tufas. They have been mapped and examined by the author throughout a large length of the Nile Valley from Qena to Cairo. Calcareous tufas, crowded with the most beautiful impressions of leaves and twigs, abound in places. At Isawia the limestones of the series are of considerable commercial importance, supplying the material for the construction of the great dam at Assiut. Finally, the fluviatile deposits include the Nile mud and other recent accumulations.

In conclusion, the author shows the probable date of the formation of the Nile Valley gorge to be Lower Pliocene, and refers it to the same great series of earth-movements which determined and formed the main physical feature of North-East Africa and part of Asia. After the deposition of the Pliocene beds a gradual elevation led to the final retreat of the sea, the valley then becoming the site of a series of fresh-water lakes in which were deposited large quantities of calcareous tufa, which enclosed the numerous leaves carried into the lakes from the surrounding forests.

Finally, "in later Pleistocene times drainage must have become well established down the Nile Valley, and a river, the youthful Father Nile, commenced its career by carving out a channel through the valley deposits, before, owing to changed conditions, it finally took to depositing layer upon layer of 'Nile mud,' thus forming the strip of cultivable and inhabitable country without which the Land of Egypt, as we know it, would be non-existent."

II.—British Association for the Advancement of Science. Bradford, 1900. Joint Discussion, Sections C and K. On the Conditions under which the Plants of the Coal Period grew.

1. Flora of the Coal-measures. By R. Kidston, F.R.S.E., F.G.S.

LEAVING out of consideration a few genera of which we possess little or no definite knowledge, the flora of the Coal-measures consists of Ferns, Calamites, Lycopods, Sphenophylleæ, Cordaites, and Coniferæ.

In genera and species the Ferns are probably more numerous than the whole of the other groups, and contain representatives of the Eusporangiate and Leptosporangiate members of the class. The Eusporangiate, or those ferns whose sporangia are unprovided with an annulus, were more numerous in the Carboniferous period than at present, though in the Coal-measures they do not appear to have been more numerous than the genera with annulate sporangia. Tree ferns, though not very common, are more frequent in the Upper than in the Lower Coal-measures, in the lowest beds of which they seem to be very rare.

The Calamites are largely represented throughout the whole of the Coal-measures, *Asterophyllites* (*Calamocladus*) and *Annularia* probably being their foliage.

Lycopods are also very numerous, and are represented by many important genera — *Lycopodites*, *Lepidodendron*, *Lepidophloios*, *Bothrodendron*, and *Sigillaria*, with their rhizomes *Stigmaria* and *Stigmariopsis*. These genera contributed largely to the formation of Coal.

The genus *Sphenophyllum* was also frequent during Coal-measure times, and forms a type of vegetation essentially distinct from any existing group.

The Gymnosperms are represented by Cordaites, Coniferæ, and Cycads.

The Cordaites had tree-like trunks and long yucca-like leaves. They are plentiful in the Coal-measures, and, like the arborescent lycopods, must have been a prominent feature in a Carboniferous forest scene.

The Coniferæ, so far as I have seen, are only represented by a single specimen of *Walchia* from the Upper Coal-measures; and though Cycads have been discovered in the Upper Coal-measures on the Continent, I am not aware of any British species which can be referred with certainty to this group.

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2. The Origin of Coal. By A. Strahan, M.A., F.G.S.

The deposition of the Coal-measures was due to the subsidence of large portions of the earth's crust to a depth often amounting to several thousand feet. The subsidence, being unequal, led to the formation of coal-basins, parts of the margins of which are still recognizable. That the intervening areas rose no less rapidly than the basins sank is proved by the vast denudation suffered by the earlier Palæozoic rocks during the Carboniferous period.

The subsidence was counterbalanced during Coal-measure times by sedimentation, for the occurrence of marine beds among deposits of a generally estuarine aspect proves that the surface was maintained at or near sea-level. The Carboniferous sediments consist, in the majority of coalfields, of marine limestones in the lower part, of marine grits and conglomerates in the middle part, and of estuaro-marine sandstones and shales in the upper part. The sequence is due, firstly, to the admission of the sea to the subsiding areas; and lastly, to the restoration of level brought about by sedimentation and denudation. But there is evidence also of the sedimentation having been more or less spasmodic. Thus the Limestone Series generally consists of repetitions of small groups of strata, each group being composed of sandstone, followed by shale, shale followed by limestone. Similarly the Coal-measures present repetitions of sandstone followed by shale, shale by coal. Limestone in the one case and coal in the other are therefore comparable in this respect, that each represents an episode when sedimentation had come to a pause. Early views as to the origin of coal, namely, that it was formed of vegetable matter drifted beyond the region to which the finest mineral sediment could reach, were in accordance with these facts.

More minute examination of the strata, however, revealed proofs of land-surfaces in the Coal-measures, and it was generally accepted that the coal-seams represent forests in the place of their growth. The evidence may be summarized as follows:—

(1) Rain-pittings, sun-cracks, and footprints prove that the surfaces of some of the beds were exposed to the air.

(2) Erect tree-trunks of large size, in some cases attached to large spreading roots, are not uncommon. Land-shells, millipedes, and the skeletons of air-breathing reptiles have occasionally been found within the hollow trunks.[1]

(3) The underclays of coal-seams are traversed in all directions by branching rootlets, unlike the drifted fragments in the bedding planes of the other strata. They were described as an invariable accompaniment of coals, and as being the soils in which the coal-forest was rooted.

(4) Coal-seams, with thin minute partings, persist over vast areas, and it was thought impossible that so wide and regular a distribution of vegetable matter could have been accomplished by drifting.

(5) The chemical composition of the coals was believed to prove that the vegetable matter underwent partial decomposition in the open air before being submerged or buried.

This evidence, however, though it proves the existence of land surfaces, is not conclusive of the coal-seams being forests in place of growth. The rain-pittings, sun-cracks, and footprints occur, not in the coals, but in the intervening strata. Of the erect tree-trunks a large proportion occur in sandstones devoid of coal, a few only having been found to stand upon an underclay, or to be associated

[1] C. Brongniart and others have shown that air-breathing insects of the orders Neuroptera, Orthoptera, Thysanura, and Homoptera, were *very numerous* in the Coal-period in Europe and America.—Edit. Geol. Mag.

with seams of coal. Vast areas of coal have been worked without any such trunks having been encountered. The majority of the trunks, moreover, are destitute of spreading roots, and are believed to have been floated to their present positions. The land-shells, insect and reptilian remains, are of extremely rare occurrence.

The underclays do not resemble soils, inasmuch as they are perfectly homogeneous, and lie with absolute parallelism to the other members of a stratified series. They are not always present beneath coal-seams, but, on the other hand, often occur in them or above them. Frequently they have no coal associated with them. The rootlets in them have no connection with the coal, which is a well-stratified deposit with a sharply defined base.

The persistence of the partings and characters of the coal over wide areas is in favour of their being subaqueous deposits, for on so large an expanse of land there must have been river-systems and variations in the vegetation. The stream-beds, known to miners as 'wash-outs,' are not proportioned in size to the supposed land-surfaces.

Subaërial decomposition of part of a mass of vegetable matter would take place whether it were floating or resting on dry land. Spores, which enter largely into the composition of many coals, would travel long distances either by wind or water.

Some coal-seams show clear proof of a drifted origin, as, for example, those which are made up of a mass of small water-worn chips of wood or bark. Other seams pass horizontally into bands of ironstone, and one case has been observed of a coal changing gradually into a dolomitic tufa, doubtless formed in a stagnant lagoon. Putting aside exceptional cases, the sequence of events which preceded the deposition of a normal coal-seam seems to have been—firstly, the outspreading of sand or gravel with drifted plant-remains, followed by shale as the currents lost velocity. The water was extremely shallow, and even retreated at times, so as to leave the surface open to the air. The last sediments were extremely fine, homogeneous, and almost wholly siliceous, and in them a mass of presumably aquatic vegetation rooted itself. This further impediment to movement in the water cut off all sediment, and the material brought into the area then consisted only of wind-borne vegetable dust or floating vegetable matter carrying an occasional boulder. Lastly, the formation of the coal-seam was brought to a close by a sudden invasion of the area by moving water. The mass of vegetable matter, often after suffering some little erosion, was buried by sandstone or shale rich in large drifted remains of plants or trees, and the whole process was recommenced.

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3. Botanical Evidence bearing on the Climatic and other Physical Conditions under which Coal was formed. By A. C. Seward, F.R.S.

Botanical investigations into the nature and composition of the vegetation which has left abundant traces in the sediments of the Coal-measures may be expected to throw some light on the natural

conditions which prevailed during that period in the earth's history that was *par excellence* the age of coal production. The minute examination of petrified tissues has rendered possible a restoration of the internal framework of several extinct types of plant-life, and has carried us a step further towards the solution of evolutionary problems. It is possible, even with our present knowledge, to make a limited use of anatomical structure as an index of life-conditions, and to restore in some degree from structural records the physiological and physical conditions of plant-life characteristic of the close of the Carboniferous epoch.

(1) *Evidence furnished by the Coal-period Floras as to Climatic and other Physical Conditions.*

The uniformity in the character of the vegetation has no doubt been somewhat exaggerated; e.g., the *Glossopteris* flora of Australia, South Africa, and South America. The existence of botanical provinces in Upper Palæozoic times.

A comparison of the Coal-period vegetation with that of the present day as regards (i) the relative abundance of certain classes of plants, (ii) the geographical distribution of certain families of plants during the Carboniferous epoch and at the present day. The importance of bearing in mind the progress of plant-evolution as a factor affecting the consideration of such comparisons. The possible existence of a Palæozoic Mountain flora of which no records have been preserved.

(2) *The Form, Habit, and Manner of Occurrence of Individual Plants as Indices of Conditions of Growth.*

Comparison of Calamites and horse-tails. Fossil forests of Calamites. *Psaronius* stems *in situ* and bearing roots at different levels, suggesting growth in a region of rapid sedimentation. Vertical stems either *in loco natali* or drifted. Climbing plants possibly represented by *Sphenophyllum*, some species of ferns and Medulloseæ. Function of the so-called *Aphlebia* leaves of ferns.

(3) *Anatomical Evidence.*

The value of evidence afforded by anatomical features. Risks of comparison between structural character of extinct and recent plants. Structure considered from the point of view of evolution, as the result of adaptation to external conditions, and to mechanical and physiological requirements.

(*a*) *Spores and leaves.* — Abundance of spores provided with filamentous or hooked appendages; adaptation of spores to floating or to wind-dispersal. The leaf structure of Calamites, ferns, etc.; presence of stomata, palissade tissue, and water-glands; the 'parichnos' or aërating tissue in the leaves of Lepidodendreæ and Sigillarieæ.

(*β*) *Stems and roots.*—Absence of annual rings of growth. The large size of water-conducting elements connected with rapid transport (e.g. *Sphenophyllum*) or with storage of water (e.g. *Megaloxylon*). The chambered pith of Cordaites, quoted as evidence of rapid elongation, of little or no physiological significance. Abundance

of secretory tissue. Anatomical characteristics of a Lepidodendroid type of stem; great development of secondary tissue in the outer cortex, little or no true cork, lax inner cortex. Lacunar tissue in the roots of Calamites; hollow appendages of *Stigmaria*. Indications of xerophytic characters may be the result of growth in salt marshes.

(4) *Evidence as to the Manner of Formation of Coal.*

(*a*) The structure of *calcareous nodules* found in coal-seams; the preservation of delicate tissues, the occurrence of fungal hyphæ, and the petrification of Stigmarian appendages as evidence in favour of the subaqueous accumulation of the plant-débris found in the calcareous nodules.

(*b*) *Ordinary coal* microscopically examined. Spores, fragments of tissues, bacteria, and the ground substance of coal. Coal found in the cavities of cells in carbonized tissues. Suggested non-vegetable origin of the matrix of coal. 'Boulders' and coal-balls included in coal-seams.

(*c*) *Boghead, Cannel coal, and Oil-shales.* Recent investigations of Bertrand, Renault, and others. The structure and mode of origin of torbanite, kerosene, shale, etc. Suggested origin of Boghead from the minute bodies of algæ (*fleurs d'eau*), spores, etc., embedded in a brown ulmic substance found on the floor of a lake. Absence of clastic material. Cannel coal characterized by abundance of spores.

(*d*) *Paper-coal of Russia.*—The paper-coal of Culm age in the Moscow basin consists largely of the cuticles of a Lepidodendroid plant. Bacterial action as an agent in the destruction of plants and as a factor in the production of coal.

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4. By J. E. Marr, F.R.S.

(1) *What is coal?*—A non-scientific term introduced into scientific nomenclature for substances of divers character, and, therefore, probably of different modes of origin.

(2) *Was the Carboniferous period one where conditions suitable to formation of coal were unusually widespread?*

Coincidence at this period of dominant giant cryptogams, extensive plains of sedimentation, and suitable climatic conditions. Such coincidence never occurred before or after the Carboniferous period.

(3) *What work should be done in order to advance our knowledge of origin of coal?*

In the past light has been thrown on coal-formation by chemical, petrological, palæontological, and stratigraphical studies, and these should be continued.

(*a*) *Chemical.*—Importance of study of chemical composition of fire-clays and other accompaniments of coal in addition to coal itself.

(*b*) *Petrological.*—Dr. Sorby's work on origin of grains of mechanically formed rocks (sandstones, etc.) should be continued.

(*c*) *Palæontological.*—Studies of faunas and floras throwing light on physical and also on climatic conditions.

(*d*) *Stratigraphical.*—Much detailed work is required in many parts of the world to discover over what periods coal-formation occurred in exceptional amount. Tendency at outset to refer all Upper Palæozoic coal-formations to the Coal-measures.

III.—On the Construction and Uses of Strike-Maps.[1] By J. Lomas, A.R.C.S., F.G.S.

In studying the deformations which a series of rocks have undergone, we are apt to regard the vertical movements as all-important, and neglect the horizontal movements to which they have been subjected. This is largely owing to the difficulties experienced in picturing such horizontal movements and representing them on a plan. Lines dependent on surface inequalities confuse the worker when he seeks to use the ordinary geological maps for this purpose. It is easy to get rid of these lines by projecting the strikes of the beds on to a horizontal plane. We then have the appearance that would be produced if the country were planed down to a horizontal surface. The outcrops would coincide with the strikes, and any deviation from straight lines would indicate horizontal movements. Vertical movements would also be shown on such a plan by the closing up of outcrops of beds of equal thickness. All the data necessary to represent these features on a strike-map are given in the ordinary Geological Survey sheets. To construct such a map, first trace the dips given on the geological map and draw short lines at the points of the arrows, at right angles to the direction of dip. We thus have represented the strikes of the beds at a number of points. Now it is necessary to connect these up by lines to show the strike at intermediate places. It would not be safe to connect one line with another, as the strikes may refer to different beds. In order to overcome this difficulty, draw a series of lines parallel to the strike line on both sides of it. On doing this for all the positions it will be found that the lines either connect themselves in linear series, or we have represented a series of tangents to curves which become evident when the lines are prolonged in the direction of the strike. Care should be taken not to connect in the same line strikes with dips in contrary directions, and it is well to represent the dip side of the strike lines by a short mark ——ı——. When the amount of dip is known, as well as the direction, we can represent the steepness of the folds by suitable shading, either by hachures or closeness of strike lines. As an illustration I exhibit strike maps of the district about Clitheroe, including the well-known knolls at Worsa and Gerna. The anticlinal ridge just north of Chatburn is clearly shown, and the strata dipping with wavy folds towards the Ribble on the north and Clitheroe on the south. The Salt Hill quarries are excavated in this southern slope at a place where the fold becomes acute. The knolls at Worsa and Gerna appear like whirls or eddies, such as may be seen in a stream when the flow is obstructed by boulders in the stream bed.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

IV.—The Concretionary Types in the Cellular Magnesian Limestone of Durham.[1] By G. Abbott, M.R.C.S.

ASSOCIATED with the Cannon-ball bed near Sunderland is a cellular limestone which is much more extensive, and exhibits still more remarkable physical features. Although described by Professor Sedgwick more than sixty years ago with other magnesian beds in the North of England, it is still comparatively unknown. He divided the concretions in these strata into four classes, but I have been unable to find any classified collection except the one in the Newcastle Museum, and even in this series it is only partially done.

My own studies at Fulwell and Hendon lead me to suggest a new classification, with *five primary forms*, viz.: (1) rods, (2) bands, (3) rings, (4) balls and modified spheres, (5) eggs. *Combinations* of these forms constitute the major part of these massive beds, and frequently a bed of less than a foot thick shows examples of several different combinations. These I place in ten classes, though they may have to be added to. The chief types are (1) tubes, (2) 'cauliflowers,' (3) basaltiform, (4) irregular, (5 and 6) troughs and bands (two kinds), (7) 'floral,' (8 and 9) 'honeycomb' or coralloid (two kinds), (10) pseudo-organic.

I exhibit photographs on the screen showing both the primary forms and the combinations as seen (wherever possible) in the undisturbed rock sections.

My own conclusions are as follows:—

1. That the rod structure is *secondary* to the formation of the conspicuous bands which run across the beds at various angles. (These bands need to be distinguished from the bands mentioned among the 'primary forms.') The conspicuous bands act as planes of origin for the 'rods,' and do not cross through the long axes of the rods themselves. They appear never to cross the bedding planes, though occasionally they follow them and also the outline of the joints. The question therefore arises, whether this does not give us a clue to the age and sequence of the changes which have occurred in these beds, and whether the previous existence of joints does not mean that the beds were already above the sea-level when the changes commenced.

2. The rods invariably start from the last-mentioned bands, and may be seen at every possible angle. As they have grown upwards and obliquely as well as downwards the term 'stalactitic' is a very misleading one to use. As Mr. Garwood stated long ago, these beds "present many points which appear irreconcilable with the theory of their stalactitic origin."

3. The first step in the series of changes which have taken place was probably an orderly but unsymmetrical arrangement of amorphous molecules of calcium carbonate which separated themselves from those of the carbonate of magnesia.

4. The internal architecture is due to such arrangement of amorphous particles of lime which has since been coated with an

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

outer crystalline layer. In some cases, however, the entire mass has undergone a complete subsequent change into a crystalline structure.

5. Pearl-spar (crystals of the combined carbonates) is seldom met with. I failed to find any.

6. In the Fulwell beds there are very few fossils, and where met with, as at Marsden, concretionary action is seldom traceable near them.

7. The specimens at Fulwell which arouse the most interest are coralloid masses ('honeycomb' of the quarrymen). They are confined, so far as I could discover, to a stratum, about $1\frac{1}{2}$ foot thick, above the marl bed, and lie in close juxtaposition to each other, which accounts for their peculiar external shape.

In conclusion I would point out the close resemblance which exists between the 'lines' and 'planes' in these concretionary beds, and the 'lines' which shoot across congealing water. In some respects the architecture of the magnesian beds compares with the ice decorations seen on our window-panes in frosty weather.

V.—The Jurassic Flora of East Yorkshire.[1] By A. C. Seward, F.R.S.

THE plant-beds exposed in the cliff sections of the Yorkshire coast have afforded unusually rich data towards a restoration of the characteristics and composition of a certain facies of Mesozoic vegetation. Rich collections of plants from Gristhorpe Bay and other well-known localities are found in the British Museum (Natural History), also in the Museums of Scarborough, Whitby, Cambridge, Oxford, Manchester, York, Newcastle, Leeds, and elsewhere. The Natural History Museum, Paris, contains several important Yorkshire plants, some of which have been described by Brongniart and Saporta. The following species have been recognized from the East Yorkshire area :—

Marchantites erectus (Leck., ex Bean MS.); *Equisetites columnaris*, Brongn.; *Equisetites Beani* (Bunb.); *Lycopodites falcatus*, L. & H.; *Cladophlebis denticulata* (Brongn.); *C. haiburnensis* (L. & H.); *C. lobifolia* (Phill.); *Coniopteris arguta* (L. & H.); *C. hymenophylloides* (Brongn.); *C. quinqueloba* (Phill.); *Dictyophyllum rugosum*, L. & H.; *Klukia exilis* (Phill.); *Laccopteris polypodioides* (Brongn.); *L. Woodwardi* (Leck.); *Matonidium Goepperti* (Ett.); *Pachypteris lanceolata*, Brongn.; *Ruffordia Goepperti* (Dunk.); *Sagenopteris Phillipsi* (Brongn.); *Sphenopteris Murrayana* (Brongn.); *S. Williamsoni*, Brongn.; *Tæniopteris major*, L. & H.; *T. vittata*, Brongn.; *Todites Williamsoni* (Brongn.); *Anomozamites Nilssoni* (Phill.); *Araucarites Phillipsi*, Carr; *Baiera gracilis*, Bunb.; *B. Lindleyana* (Schimp.); *B. Phillipsi*, Nath.; *Beania gracilis*, Carr; *Brachyphyllum mammillare*, Brongn.; *Cheirolepis setosus* (Phill.); *Cryptomerites divaricatus*, Bunb.; *Ctenis falcata*, L. & H.; *Czekanowskia Murrayana* (L. & H.); *Dioonites Nathorsti*, sp. nov.; *Ginkgo digitata* (Brongn.); *G. whitbiensis*, Nath.; *Nageiopsis anglica*, sp. nov.; *Nilssonia compta* (Phill.);

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

N. mediana (Leck., ex Bean MS.); *N. tenuinervis*, Nath.; *Otozamites acuminatus* (L. & H.); *O. Beani* (L. & H.); *O. Bunburyanus*, Zign.; *O. Feistmanteli*, Zign.; *O. graphicus* (Leck., ex Bean MS.); *O. obtusus* (L. & H.), var. *ooliticus*; *O. parallelus* (Phill.); *Pagiophyllum Williamsoni* (Brongn.); *Podozamites lanceolatus* (L. & H.); *Ptilozamites* (Leck., ex Bean MS.); *Taxites zamioides* (Leck.); *Williamsonia gigas* (L. & H.); *W. pecten* (Phill.).

The English flora is compared by the author with Rhætic, Jurassic, and Wealden floras of other regions; a comparison is made also between the fossil flora and the vegetation of the present day.

VI.—On the Fish Fauna of the Yorkshire Coalfields.[1] By Edgar D. Wellburn, F.G.S.

ONLY the Lower and Middle Coal-measures are present. The author described the Lower Measures, their extent and general characters, with their beds of marine and fresh-water origin. The Middle Measures and their general character: formed in a series of fresh-water lake basins. The author described the fish-remains, where found and in what state of preservation. Elasmobranchs, Teleosteans (and in some cases Dipnoans), commingled, i.e. marine and fresh-water types in the same beds; Elasmobranchs found in marine and fresh-water beds; Dipnoi only found under fresh-water conditions. Teleostean orders, Crossopterygii and Actinopterygii found in both fresh-water and marine beds. The conditions under which coal was deposited was shown to have a bearing on the occurrence and habits of the fishes. The swim-bladder of Cœlacanths, and its peculiar use to them under certain conditions. The Elasmobranchii were represented by eleven genera and twenty-three species; Ichthyodorulites by seven genera and eight species; Dipnoi by two genera and two species; and the Teleostomi by twelve genera and thirty-three species. A tabular list of fish-remains was given showing their stratigraphical distribution; several new fish-bearing coal shales were recorded, the distribution and vertical range of the Yorkshire coal-fishes being thus greatly extended; several genera and species new to Yorkshire, and others new to science, were referred to by the author.

REVIEWS.

I.—Catalogue of the Bateman Collection of Antiquities in the Sheffield Public Museum. Prepared by E. Howarth, F.R.A.S., F.Z.S., Curator of the Public Museum and Mappin Art Gallery. 8vo; pp. xxiv and 254, with 262 illustrations in the text. Published by order of the Committee. (London: Dulau & Co., 1899. Price 3*s.* 6*d.*)

THE very valuable and interesting collection which forms the subject of this excellent Catalogue is not only entirely British, but is confined to Derbyshire, Staffordshire, and Yorkshire, and is the work of three generations of Batemans of Middleton Hall,

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

Derbyshire, from 1759 to 1847, assisted by Mr. Samuel Carrington in Staffordshire, Mr. James Ruddock in the North Riding of Yorkshire, Mr. Stephen Glover in Derbyshire, and Mr. Samuel Mitchell of Sheffield, an antiquary of wide erudition.

Following the Collection, the Catalogue is arranged as under, viz.:

Celtic Period: Stone and bronze weapons and utensils, Nos. 1–526, pp. 1–89; urns and other pottery, Nos. 757–896, pp. 91–156; miscellaneous objects, crania, querns, Nos. 897–985, pp. 157–174; tools, personal ornaments, Nos. 527–598, pp. 175–190.
Romano-British Period: Nos. 599–687 and 986–1117, pp. 191–218.
Anglo-Saxon Period: Nos. 688–756, pp. 219–231.
Miscellaneous Objects: Nos. 1118–1288, pp. 232–254.

In his excellent Introduction Mr. Howarth observes that: "Records of the dead are almost the only means whereby any reliable account can be constructed of the life and customs of the earliest inhabitants of Britain, with whom writing was unknown; pictorial art, if not quite beyond their skill, was of the simplest kind, and their dwellings were of such a temporary and unsubstantial character that all traces of them vanished before the historical period. The care of the dead forms their most lasting memorials, and it is these sepultural mounds that furnish the principal information respecting the early Britons. Derbyshire has contained many conspicuous examples of ancient barrows, tumuli, or grave-mounds, and, fortunately, amongst the Bateman family there were men of leisure, means, and knowledge, with the taste for exploring these sepulchral storehouses and carefully preserving them; and it was chiefly owing to the labours of Mr. Thomas Bateman that the collection which bore his family name was formed." (p. v.)

"Under the Celtic Period are grouped all those objects found in the burial-places, or in any way associated with the ancient Britons, whether belonging to the round-headed or long-headed races, two distinct types which may have sprung from two different groups afterwards associated together. Authorities agree in regarding the earliest race inhabiting these islands as Celts, and as the exact indications of time are few there is the freer scope for the imagination. Let us take it, then, that 1600 years before Christ, Britain was inhabited by a Celtic race of long-headed men of low mental development and small stature. The Phœnicians traded with Britain for tin, lead, and skins, 600 years before Christ; and about 500 B.C. Hecatus, a Greek writer, describes Britain as an island opposite the coast of Gaul about as large as Sicily.

"In or about the year 350 B.C. the Belgæ, a tribe descended from the Scythians, invaded the island. They were men of larger stature than the Celts, their heads were round rather than long, and they were inured to the dangers and hardships of war. The Belgæ conquered and occupied the southern and south-western counties, driving the Celts to the north and north-west. When the Romans invaded the island, first in 55 B.C. under Julius Cæsar, and about a century later in the reign of Claudius, the Belgæ were the tribes

first encountered. The skulls found in the barrows mainly belong to the round-headed type, some of them being mesaticephalous, representing the characters of the two types." (p. vi.)

It is interesting to notice the "very great care and trouble expended over the construction of many of the grave-mounds, probably those in which were deposited chiefs of tribes or important individuals of the community, for it is impossible that these huge mounds, which sometimes contain only a single interment, and never very many, could have been constructed for all the people who died. It is these barrows or tumuli which furnish the evidence of the customs, habits, and rites of these ancient people.

"The chief characteristic of a Celtic place of burial is a large mound, sometimes circular, in other cases oval, and more rarely long-shaped, the latter being regarded as the most ancient. These mounds differ considerably in dimensions, from 20 to 200 feet in diameter and from 1 to 24 feet in height. They were usually placed in a conspicuous position on or near the summit of some natural elevation of the land. The mounds of earth and stone are called barrows, and are formed of materials from the immediate neighbourhood of the situation in which they were placed. In some cases a mound of stones or a cairn was erected over the dead." (p. vii.)

Burial by Cremation.—"Where the bodies were cremated the ashes were afterwards carefully collected together, tied up in some fabric, and placed on the ground; or they were covered by or put into an urn, and frequently placed in a cist or in a cavity hewn in the rock."

Ordinary Interment.—"*Inhumation* was the more common mode of burial, the body probably being wrapped in some skin or garment, for although these have long since perished, pins, buttons, and other articles found in barrows indicate that they were used as fastenings for sepulchral clothing of some kind. Some barrows contain burnt and unburnt bones, one body having been interred in the position in which it died, while the others were burnt; and it may be inferred from these occurrences that the sacrifice of human life at the death of a chief was practised amongst the ancient Britons, as is the custom in recent times with many uncivilized races. The wife, children, or slaves may thus have been immolated to keep the head of the family company in a future world." (p. viii.)

Objects found in Celtic Tumuli and Barrows.—"The contents of the graves lead strongly to the supposition that belief in a future state was held by these primitive people, provision evidently being made for them to carry on their work and amusements. Besides the cinerary urns, which were obviously intended to contain the cremated bones, other vessels of three distinct types have been found with interments, both of burnt and unburnt bodies. These are generally known as food-vessels, drinking-cups, and incense-cups, though it must not be inferred that they were strictly used for the purposes implied in those names." (p. viii.)

"Implements and weapons, both in stone and bronze, are

frequently found in barrows, as also personal ornaments in the shape of necklaces, glass beads, buttons, bronze and bone pins. Numerous examples of these finds are recorded, amongst them being some pieces of red ochre, the rouge of that period, used for decorating the body. Although the use of iron was then unknown, pieces of rubbed and polished iron-ore have been found in barrows, as if they had some special significance as charms.

"Stone and bronze weapons are sometimes found in the same grave, the two materials evidently being used at the same period, probably this marking the time when bronze first came into use and before it had been generally adopted. A leaf-shaped dagger is the principal bronze weapon found in a grave, bronze implements being much less numerous than those of stone. The pins in bronze and bone and the buttons in Kimmeridge Coal show that some form of dress was worn which these were intended to fasten." (p. ix.)

Mr. Howarth draws the following conclusions:—"It would appear from the teachings of the tombs of the ancient Britons that they were in a semi-savage state, without any fixed religion, with the sagacity to make tools, vessels, weapons, and implements for daily use. That the use of stone only gradually gave place to the use of bronze from an acquired knowledge of the properties of the ores of copper, tin, zinc, and lead. While no special differentiation of purpose is shown in their manufactures, yet they indicated a separation of certain objects for distinct uses. Clothing was worn amongst them, consisting of skins and probably manufactured stuffs, such as jute and flax. They cultivated the soil to a certain extent, and had domestic animals for labour and sustenance. While believing in a future state, their ideas of religion were of a very vague character, and they still practised certain barbarous rites which belong only to savages. The period which is covered by the history of Celtic barrows probably extends over many hundreds of years, and they show the advance the people had made during that time, ranging through the later or neolithic stone-period to the opening of the age of bronze, the people of the Palæolithic period being much more ancient than the architects of these barrows, and of a much more primitive type." (p. xviii.)

Space does not permit us to give a fuller notice of this very excellent and well-illustrated Catalogue and Guide to one of the most valuable collections of its kind to be seen in any museum in this country. We venture to suggest to the author that the very beautiful necklaces, said to be of 'Kimmeridge Coal,' figured on p. 59 (J. 93, 431, G. 79), p. 61 (J. 93, 434, G. 113), and p. 63 (G. 158), were really originally made of jet from Whitby, which, owing to damp, etc., have lost their pristine lustre and become decomposed by age and long interment in the earth, until they resemble Kimmeridge Coal or 'Brown-coal' in aspect. We compliment Mr. Howarth upon the production of this excellent Catalogue of the Bateman Collection, and the Committee of the Sheffield Museum in authorizing the publication with such ample illustrations. The Collection itself is well worthy of a pilgrimage to Sheffield, nor is it the only one to be seen in this admirable Museum.

II.—The Geology of the Country between Atherstone and Charnwood Forest. By C. Fox-Strangways, F.G.S. With Notes on Charnwood Forest by Professor W. W. Watts, M.A., F.G.S. 8vo; pp. 102. (London: printed for H.M. Stationery Office, 1900. Price 2*s*.)

THIS Memoir, which has been written in explanation of the New Series map, Sheet 155, contains a good deal of detailed information of practical value respecting the northern part of the Warwickshire Coalfield and the southern part of the Leicestershire Coalfield. A number of records of borings and sinkings are given. Professor Watts contributes a summary of the interesting observations which he made while mapping in detail the old rocks of Charnwood Forest. These he groups in the 'Charnian System,' whose position in the great Pre-Cambrian sequence cannot at present be determined. Among the other rocks dealt with by Mr. Strangways are the Stockingford Shales (Cambrian), the Permian and Trias, the Glacial, and more recent deposits. With the aid of Mr. Whitaker he contributes a useful geological bibliography of Leicestershire.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 7, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Additional Notes on the Drifts of the Baltic Coast of Germany." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and the Rev. E. Hill, M.A., F.G.S.

The authors, prior to revisiting Rügen, examined sections of the Drift to the west of Warnemünde, with a view of comparing it with that of the Cromer coast. Where the cliffs reach their greatest elevation, two or three miles from that town, they are composed of a stony clay, which occasionally becomes sandy. At intervals, however, sand interbanded with clay occurs, filling what appear to be small valleys in the Drift. A layer of grit and stones, occasionally associated with a boulder, occurs once or twice between these sands and clays. The valleys are excavated in the great mass of stony clay which extends for four or five miles to the west of Warnemünde; and the synclinal slope of the layers and the contortion of the underlying bedded sands indicate that the mass filling them has been let down as a whole, either by solution of the Chalk beneath the Drift or by the melting of underlying ice. Of these two hypotheses the authors view the latter with the more favour, but it also has its difficulties.

In Rügen, Arkona was visited; here Chalk occurs, apparently as a sort of island in the Drift. At the well-known locality by the lighthouse it seems to overlie a drift, but on closer examination the latter appears more probably to have filled a cavity excavated in the Chalk, this apparent inlier of Drift probably being only a remnant of a much larger mass; therefore it is likely that this part of the

coast nearly corresponds with a pre-Glacial chalk-cliff against which the Drift was deposited.

In the Jasmund district the authors lay special emphasis on three points:—(1) The 'inliers' of Drift appear to occupy valleys excavated in the Chalk; (2) these valleys can be traced for some distance inland; (3) the steep walls of Chalk towards which the Drift dips sharply, and against which it ends abruptly (usually on the southern side), often trend gradually inland, as if the present coastline had passed obliquely across an old valley. In one or two instances the Drift is slightly twisted up against this steep face of Chalk. The authors call attention to cases where the Drift clearly rests against old surfaces and cliffs of Chalk; and to one in particular, which was not visible in 1898, where (*a*) clay, (*b*) sand, and (*c*) clay occupy a shallow valley, and have assumed a synclinal form. The authors give reasons to show that neither solution of the Chalk, nor ice-thrust, nor folding, nor even faulting, can satisfactorily explain the peculiar relations of the Drift and Chalk in Rügen; and they can find no better explanation than that offered in their previous paper.

2. "On certain Altered Rocks from near Bastogne and their Relations to others in the District." By Catherine A. Raisin, D.Sc. (Communicated by Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.)

Professor Renard, from the petrographical study of specimens, and Professor Gosselet, after description of the district and its stratigraphy, have attributed the changes in these rocks to mechanical disturbances. Dumont had previously described many examples and inclined to the view of contact-alteration, which was favoured by Von Lasaulx's discovery of a granite in the Hohe Venn and M. Dupont's identification of chiastolite from Libramont.

The present paper treats especially of the garnetiferous and hornblendic rocks, giving the full petrographical and field details of a few examples. It points out that the effects of pressure are evident over the whole district, while mineral modifications resembling the results of slight contact-action are found in certain areas. In a few cases these modifications are more marked, and sometimes increase as we approach veins composed of quartz, felspar, and mica, such as might be connected with a concealed granite.

The peculiar garnetiferous and hornblendic rocks, although occurring within the zone of alteration, are extremely limited, often forming patches or bands a few feet across. They differ, as described in the paper, from ordinary contact-altered rocks. The evidence, in the authoress's opinion, is in favour of Prof. Bonney's suggestion that they are due to some form of hot-spring action.

II.—Nov. 21, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "A Monchiquite from Mount Girnar, Junagarh (Kathiawar)." By John William Evans, D.Sc., LL.B., F.G.S.

After a brief account of the rocks of the monchiquite type, in which ferromagnesian silicates are embedded in an isotropic matrix with the chemical constitution of analcime, the author describes an example from Mount Girnar, where it is associated with a nepheline-syenite intrusive in a mica-augite-diorite.

The most striking feature of this rock is the occurrence of colourless spheres of various sizes up to about 1 mm. in diameter. The rest of the rock is mainly composed of a hornblende of the barkevikite type; a pale-green augite is also present. Both the spherical spaces and the interstices between the ferromagnesian silicates are usually filled with an isotropic material which has the composition and most of the physical properties of analcime. This material does not, however, show the anomalous double-refraction which is characteristic of that mineral, nor has it any crystalline outlines, being simply an allotriomorphic glass-like groundmass. It contains a large number of acicular inclusions, most of which do not affect polarized light; they exhibit a parallel arrangement in one or more directions, and appear to indicate a high degree of symmetry. Cleavage-cracks with similar orientation may be occasionally observed. As it is clearly a crystalline body, its isotropic nature refers it to the cubic system, and its identity with analcime may be considered proved. It is evident that this mineral, growing outward from different centres, has formed the spherical spaces by pushing aside the previously crystallized minerals until they came into contact one with the other, and has afterwards crystallized in the interstices between them.

The presence of a groundmass of analcime (or one having the same composition) in all the members of the widely distributed monchiquite group of rocks implies the occurrence in different localities of a residuary magma of uniform composition, which remains liquid after the other constituents of the rock have crystallized out. Analcime must, therefore, represent an eutectic compound. If the cooling were sufficiently rapid the magma would consolidate as a glass, as may be the case with some monchiquites. On the other hand, where such a magma has separated and cooled slowly enough, a nepheline-syenite will be formed.

At some points the analcime in the spheres and in the interstices has become decomposed into alkali-felspars and nepheline, as in the pseudo-leucites of Dr. Hussak, so that in these places the rock might be described as a hornblende-tinguaite. In other parts much of the analcime has passed into cancrinite.

The presence of a mineral of the eudialyte-eucolite group is also noticed.

2. "The Geology of Mynydd-y-Garn (Anglesey)." By Charles A. Matley, Esq., B.Sc., F.G.S.

Mynydd-y-Garn, a hill of less than 600 feet elevation, stands above the village of Llanfair-y'nghornwy in North-West Anglesey. The mass of the hill is an inlier of sericitic and chloritic phyllites (Garn Phyllites), surmounted by a massive conglomerate (Garn

Conglomerate), and surrounded by black slates and shales of apparently Upper Llandeilo age. The general dip of all the rocks is northerly and north-easterly.

The Garn Phyllites are usually green altered shales and fine gritty rocks, and are intensely contorted near their southern boundary. Even where not contorted they show under the microscope evidence of powerful earth-movement. They are considered by the author to be part of the 'Green Series' of Northern Anglesey. They are cut off to the west and south by a curved fault, probably a thrust, which brings them against Llandeilo slates and breccias.

The Garn Conglomerate, Grit, and Breccia, a formation perhaps 400 feet thick, rests upon the Garn Phyllites and contains fragments derived from them, as well as pebbles of quartz, grit, gneissose and granitic rocks, etc. It passes up gradually into black slates, from which a few Upper Llandeilo fossils have been collected. In the black slates an oolitic ironstone or ferruginous mudstone has been found, which may perhaps be on the same horizon as the similar rock recorded by the author in Northern Anglesey.

On the eastern side of Mynydd-y-Garn is another group of rocks, the Llanfair-y'nghornwy Beds, which the author correlates with the basal part of his Llanbadrig Series. They consist of phyllites resembling those below the Garn Conglomerate, but they contain also beds and masses of quartzite, grit, and limestone. They are much broken, and partly in the condition of crush-conglomerates. They have been thrust over the Llandeilo black slates, and the thrust-plane has been traced to the coast at Porth yr Ebol. This thrust is continuous with that which forms the southern boundary of the 'Green Series' of Northern Anglesey.

The district around Mynydd-y-Garn has been affected since Llandeilo times by two powerful earth-movements, acting one from the north, the other from the north-east. The first-mentioned prevailed in the area west and north-west of the hill, where the pre-Llandeilo rocks are frequently shattered to crush-conglomerates. Around Mynydd-y-Garn itself and east of it the principal direction of movement has been from the north-east; south of the hill the structure is perhaps the result of the interference of these two movements.

3. "On some Altered Tufaceous Rhyolitic Rocks from Dufton Pike (Westmorland)." By Frank Rutley, Esq., F.G.S. With Analyses by Philip Holland, Esq., F.I.C., F.C.S.

The specimens described were collected by the late Prof. Green and Mr. G. J. Goodchild from the Borrowdale volcanic series which constitutes the central mass of Dufton Pike, and the chief interest attaching to them is their alteration, probably as the result of solfataric action. One of the rocks, which has the composition of a soda-rhyolite, contains felspar, augite, magnetite, and possibly spinel or garnet, scapolite, and ilmenite. The porphyritic crystals of felspar are much corroded, and are sometimes mere spongy masses in which mica and opal-silica have been developed, together with small

quantities of carbonates. In a second example, felspar fragments appear as a meshwork of rods which extinguish simultaneously, and are embedded in an isotropic groundmass crowded with globulites and little rods. A faint streakiness, which cannot be fluxion-structure, passes through the matrix of the rock and the meshwork of the felspar fragments without deflection. Analyses of the rocks and diagrams constructed from their molecular ratios correspond closely with those of soda-rhyolite and potash-rhyolite respectively.

III.—Dec. 5, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Corallian Rocks of St. Ives (Hunts) and Elsworth." By C. B. Wedd, Esq., B.A., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

Starting 2½ miles south-west of Elsworth, the author traces the Elsworth Rock at intervals through Croxton, Yelling, Papworth Everard, etc., to Elsworth, and thence towards Fen Drayton and near Swavesey. The Oxford Clay is found to the west of it, and the Ampthill Clay to the east. Frequent fossil lists are given, and the character of the rock is described at the different exposures. Again, from Haughton Hall, west of St. Ives, the 'St. Ives Rock' is traced through that town and towards Holywell. The actual connection with the Elsworth Rock cannot be seen owing to an area of fen. But that the two rocks are identical the author considers is proved by the consistency of the two rocks, the absence of any other rock-bed, the dip of the strata, and the presence of Ampthill Clay above. The Corallian strata of the area appear to have been deposited more slowly than the Oxfordian strata. Of the two zonal ammonites of the Corallian, the dominant form in the Elsworth Rock and in the stone-bands of the Ampthill Clay is of the *plicatilis* and not the *perarmatus* type.

2. "The Unconformity of the Upper (red) Coal-measures to the Middle (grey) Coal-measures of the Shropshire Coalfields, and its bearing upon the Extension of the latter under the Triassic Rocks." By William James Clarke, Esq. (Communicated by W. Shone, Esq., F.G.S.)

The Upper Red Measures have a much greater extension in the Shropshire Coalfields than the productive measures below. In the Shrewsbury field they are the only Carboniferous rocks present, and rest on pre-Carboniferous rocks.

When the sections of collieries at and near Madeley are plotted on the assumption that the base of the Upper Carboniferous rocks is horizontal, the Lower Measures are found to be bent into a syncline rising sharply to the north-north-west and more gently to the south-south-east. A second syncline, broader and deeper, extends from Stirchly towards Hadley, but the westerly rise is often hidden by the boundary-fault of the coalfield. This phenomenon is known locally as the 'Symon Fault'; and instead of taking Scott's view that it represents a hollow denuded in the Lower Coal-measures, the author considers it due to folding before late Carboniferous times.

A third little syncline occurs at the Inett and Caughley. Similar phenomena are exhibited in the Forest of Wyre Coalfield, where a series of unproductive measures come in between the Lower and Upper Coal-measures. The axis of the folds runs east-north-eastward, and their amplitude and length diminish in proceeding from north-west to south-east. Inter-Carboniferous folds also occur in the North Wales and North Staffordshire fields.

3. "Bajocian and Contiguous Deposits in the Northern Cotteswolds: the Main Hill Mass." By S. S. Buckman, Esq., F.G.S.

After giving comparative sections at Cleeve, Leckhampton Hill, and Birdlip, to show the disappearance of three horizons at the second locality and five more at the third, the author interprets the absence of the beds as due to 'pene-contemporaneous erosion,' brought about by the elevation of rocks, due to small earth-movements along a main south-west to north-east axis and subsidiary axes north-west to south-east. In the Northern Cotteswolds the beds which come in at Cleeve disappear, while there is a development of the Harford Sands, the Tilestone, and the Snowshill Clay above the Lower *Trigonia*-Grit. A series of detailed sections along the main hill-mass is given. On tracing the rocks from west to east across the Northern Cotteswolds, the whole of the Inferior Oolite disappears, except quite the upper portion, which rests directly on Upper Lias, and the Upper Lias itself undergoes denudation; eastward the latter thickens again, and basal beds of Inferior Oolite reappear. Thus the axis of an important anticline is along the Vale of Moreton. The general result of the observations does not confirm Professor Hull's view that these members of the Jurassic are thinning and disappearing eastward. The observed phenomena were really brought about by contemporaneous erosions; whereof the principal one occurred before the deposition of the Upper *Trigonia*-Grit. A revised map of Bajocian denudation is given, and it is shown that, owing to anticlinal axes along the Vales of Bourton and Moreton, pene-contemporaneous erosion must have had considerable influence in determining the position of these valleys. Such erosion is likely to have taken place along similar lines at different times, and therefore may be connected with folds in Palæozoic rocks and may have a bearing on the thickness of rocks overlying the Coal-measures. A table of the dates of the chief erosions in Jurassic times is appended to the paper.

OBITUARY.

CHARLES JOHN ADRIAN MEŸER.

Born May 23, 1832. Died July 16, 1900.

By the death of Mr. Charles Meÿer we have lost a geologist who has contributed largely to our knowledge of Cretaceous rocks and fossils. He belonged to a family in whom a love of natural history was inherent, and from the time of his leaving school until his appointment to the Civil Service he greatly assisted in the preparation of a new edition of H. L. Meÿer's "Illustrations of British

Birds." Always a careful and patient observer, he acquired a close acquaintance with the habits and song-notes of British birds, and never ceased to take an interest in them.

In July, 1857, he was appointed to a post in the Accountant General's Office of that time, in a division which was subsequently transferred to the Chancery Courts under the title of the Supreme Court Pay Office. At that time his family lived near Godalming, and his attention was attracted to the fossils to be found in an old quarry in the Lower Greensand near the house. These interested him so much that he began to study them and the rocks containing them, and this laid the foundation of that interest in geology which bore good fruit in after years. From that time he always devoted his short holidays to visiting places of geological interest, chiefly along the south coast, and almost always where rocks of Cretaceous age were to be seen.

He had a remarkably keen eye for fossils, and knew the value of recording the exact bed from which they came; hence his notebooks contain carefully measured sections, and his published papers show that he had always the correlation of beds in different places before his mind.

He gradually gathered together a fine collection of Cretaceous fossils, comprising many thousand specimens, obtained entirely by his own hands. It comprises fossils from the Lower Greensand, Gault, 'Upper Greensand,' and Blackdown Beds, from the Devonshire Cenomanian, and from the several stages of the Chalk, and it contains many unique specimens. This collection, by the generosity of his sister, Miss C. Meÿer, has been presented to the University of Cambridge, together with a smaller but fine collection of London Clay fossils collected by his brother, Mr. Christian H. Meÿer, C.E., during the dockyard extension works at Portsmouth.

The first paper published by Mr. C. J. A. Meÿer was a note on the age of the Blackdown Beds in 1863, and from that time to 1878 he contributed frequently to the pages of the Geological Magazine and of the Quarterly Journal of the Geological Society. A list of his papers is given below, but two of the most notable may be specially mentioned.

In his paper "On the Relations of the Wealden and Punfield Formation" he took a view which was opposed to that held by another well-known geologist, and maintained it with such success that it is now generally accepted as correct.

His paper on the Cretaceous Rocks of Beer Head is really a very condensed account of his exploration of the Devon cliffs from Sidmouth to Lyme Regis. He visited this coast again and again, collecting carefully from every bed in the succession; and as he was practically the first to explore this fine collecting ground, he obtained a large number of excellent specimens, especially from those beds which he numbered 10, 11, and 12, and which lie at the base of the Chalk. He continued to collect from these cliffs for many years after the publication of his paper, and the value of his researches was acknowledged by Messrs. Jukes-Browne and W. Hill